PRACTICAL ANATOMY

AN EXPOSITION OF
THE FACTS OF GROSS ANATOMY FROM THE
TOPOGRAPHICAL STANDPOINT AND A GUIDE
TO THE DISSECTION OF THE HUMAN BODY

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WITH 366 ILLUSTRATIONS, OF WHICH 225 ARE IN COLOR
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PREFACE

WHILE it is essential for the student of anatomy to use a systematic treatise upon descriptive anatomy both for systematic study and as a work of reference, it is a distinct advantage to him to approach the subject from the regional or relational point of view as well. As this is the method of study necessarily pursued in the dissecting room, a book of this kind becomes logically the companion and guide of the student in the prosecution of his study of the cadaver. In recognition of this fact, the details of each region are presented in the order of dissection, and the illustrations are arranged serially, as nearly as possible, in order to show clearly the structures to be encountered at successive stages of the work. To facilitate the student's work still further, directions are given as to the technic of dissection and as to the definite order of procedure in exposing and identifying the various structures of each region.

Since this work in no sense attempts to usurp the functions of a textbook of descriptive anatomy, much descriptive detail has been omitted; at the same time an effort has been made to preserve the logical order of the subject to as great degree as seemed compatible with the object in view.

It is a well-recognized fact that students of human anatomy, even at the beginning of their course, evince a livelier interest in the subject when the relations of structures to the practical facts of medicine and surgery are brought to their attention than when they study the various systems in a more or less abstract way. Therefore, any point of special clinical interest concerning any structure under discussion is mentioned in connection with that structure. That the beginner may not be unduly distracted, however, by over-abundance of such references, they have been set apart from the body of the text by presentation in smaller type.

Although the cadaver has been divided into four "parts," the aim has been so to present the material as to permit of freedom of choice in this respect.

Conceding the desirability of uniformity and simplicity of terminology in anatomy as in any other science, but believing that the adop-

tion of a new terminology for any science is just as truly a matter of gradual evolution as the development of the nomenclature already in use or as the growth of language in general, the acceptability of new terms being conditioned upon expediency and convenience as well as upon certain intangible factors not easily definable, the Basle anatomical nomenclature has not been adopted in its entirety in this book. In many cases the BNA terms have been used directly; where not so employed they have been added in parenthesis. While the sweeping out of existence—at least of text-book existence—of the many awkward and cumbersome terms in current use would be "a consummation devoutly to be wished," as a matter of fact they do exist and most probably will exist for some time to come; their retention for the time being in a book of this character seems to be necessary therefore, even though it be understood that they are retained as undesirable tenants.

The illustrations have been made, for the most, from the author's dissections and under his direct supervision, many of them having previously appeared in Piersol's Anatomy. For the use of the drawings not so made, viz., those of the larynx, those of the brain except Figs. 233–235 and 256 to 260, those of the ear except Fig. 204, as well as Figs. 165, 284, 302, 325, 327, 328, 337 to 340, 343, and Figs. 353–355, the author is indebted to the courtesy of the editor of Piersol's Anatomy. Of the 366 illustrations, 171 were made specifically for this work, including the entire series of joint-pictures, except Figs. 74 and 76, the drawings of the mammary gland, of the axillary lymphatics, of various parts of the upper extremity; of Scarpa's triangle, the popliteal space, the suprapatellar bursa, the malleolar regions; many of those of the neck and head; those of the male external genitalia, of the abdominal walls and viscera in part, of the peritoneal fossæ and of the mediastinal spaces.

The author would take this opportunity to express his appreciation of the work of the artist Mr. E. F. Faber, and of the courtesy and generosity of the publishers.

JOHN C. HEISLER.

PHILADELPHIA, July 1, 1912.

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PRACTICAL ANATOMY

INTRODUCTION.

The plan laid down in the following pages for the dissection of the human body provides that the properly preserved cadaver should be placed upon the table in the lithotomy position for the first few days after its reception into the dissecting-room in order that the dissection of the perineum may be effected while the parts are still fresh and while their relations are as yet undisturbed by work upon adjacent regions. This position will not interfere with work upon the head, but the dissection of any other part of the body must be deferred until the perineum shall have been completed.

The adequate protection of the subject against drying of the skin and consequent deterioration of the superficial structures is a point that cannot be too strongly insisted upon. The cadaver may have been well cared for—by anointing the surface with vaseline and bandaging—up to the moment of its entrance into the dissecting-room, but if the dissector fails to exercise like care and needlessly exposes portions of the body or of his "part" upon which he is not at the moment engaged, he will be apt to find, after a few weeks, that the regions thus neglected will be either totally worthless or that their usefulness is much impaired. If, therefore, the limbs have been bandaged, the bandages should be displaced only to the extent necessary for the work of the day and, at the end of each day's work, the dissection should be covered with damp but not excessively wet cheese-cloth, and the entire body should be carefully covered with rubber sheeting, the edges of which should be tucked under the body instead of being allowed to hang down about the table. The cheese-cloth, a pad of which may, with advantage, be placed beneath the skin-flap while a second pad is placed over the skin, may be wrung out of a solution of carbolic acid two parts, glycerin eight parts and water ninety parts.

One of the first essentials to successful work on the cadaver is sharp knives; the dissector can do nothing worth while without them. The proper use and care of knives will obviate the need of frequent sharpening and thus become an important factor in economizing time. The smaller knives should be used only for the softer tissues and their cutting edges should be guarded against contact with hard substances; they

FIG. 1.—Raising the skin-flap.

FIG. 2.—Raising a flap of superficial fascia, the fingers of the left hand making counter-tension on the deep fascia.

should therefore be placed carefully in a proper case after use instead of being carelessly thrown together. In addition to the use of the stone for sharpening very dull instruments, the dissector will find a razor-strop to serve a useful purpose; blades carefully honed on the strop will only occasionally require the stone if otherwise well cared for. Small leaden weights of from two to four ounces, attached to a six- or eight-inch length of chain to the opposite end of which a hook is affixed, are useful for retracting a flap of fascia or skin or for pulling aside a nerve or vessel.

The Removal of the Integument.—In making the incisions, directions for which will be found in the sections pertaining to the several "parts," care must be exercised to avoid cutting too deeply. Grasping with the forceps a corner of the flap outlined by the incisions, a few light cuts should be made close to the deep surface of the skin, the flap being pulled upon sufficiently to show the line of separation between the skin and the subcutaneous tissue. It is often desirable to discard the forceps after the raising of the flap has been well begun and to hold the latter with the fingers. Frequent moistening of the subcutaneous tissue materially aids the work. Continuing the traction on the raised flap of skin and still taking care to make the knife-cuts close to its deep surface with the blade of the knife in a plane approximately parallel with the latter (Fig. 1), the denudation should be carried to the extent necessary fully to expose the region to be dissected. As the skin itself is one of the best protectives for the soft parts beneath, the flap is to be removed as nearly as possible without mutilation in order that it may be replaced at the end of the day's work.

The Dissection of the Superficial Fascia.—This lamina may be removed as a flap, the two strata into which it is separable in certain regions being taken up in succession; when the superficial nerves and vessels which ramify within it are to be dissected, its preservation as a distinct sheet is scarcely feasible, since the working out of these structures necessarily results in more or less mutilation of the fascia. When a flap is to be reflected, the lines of incision should follow those made in the skin, a corner of the outlined flap being raised with the forceps. A little traction upon the part thus elevated will reveal the natural lines of separation between the superficial fascia and the deep, when light touches of the scalpel along the angle between these two strata will effect their separation. In some cases a certain amount of counter-tension upon the deep fascia or upon the deep layer of the superficial fascia when the object is the separation of the superficial layer from the latter may be made in the manner shown in Fig. 2. In certain regions, such as the scrotum, it is sometimes possible to effect the separation in part at least by this means without the use of cutting instruments, the strata being, as it were, "peeled" apart.

FIG. 3.—Dissecting the connective tissue from the surface of a small artery.

FIG. 4.—Following a nerve, the intercosto-humeral, made taut by elevation upon a finger.

The superficial layer of the superficial fascia is to be differentiated from the deep layer by the fact that the former contains the greater quantity of fat while the latter is more distinctly membranous in character. Here again, as in the removal of the skin, frequent moistening of the tissues, unless they are already sufficiently succulent, will much facilitate the work.

The Dissection of Superficial Vessels.—Upon exposure of the superficial fascia the superficial veins are easily recognized, especially if they have been injected. The arteries are somewhat less obvious, being covered in many cases by fatty tissue. In a well-injected subject the finer arterial twigs, which are more superficially placed, serve as guides to the larger vessels. When either an artery or a vein is seen shimmering through the covering tissue, the latter should be pinched up with forceps and dissected away from the vessel as shown in Fig. 3. The superficial aspect of the vessel having been thus denuded, it is a comparatively simple matter to complete its isolation by making light cuts through the fascia close to the vessel and parallel with its course. It is often convenient to raise an artery or a vein upon a finger after a small portion of it has been denuded, thus making its further course as well as its branches more evident, but this is always to be done cautiously, making rather slight tension.

The Dissection of the Superficial Nerves.—The nerves found in the superficial fascia may be easily overlooked as they are usually quite effectually masked by the adipose tissue, being situated, except the quite small twigs, in the deepest part of the superficial fascia. The proper method of procedure is to acquaint one's self first with the cutaneous nerves to be found in the region in question and with their typical course. Having done this, the surface of the superficial fascia should be closely scrutinized to detect the nerves, which, as seen through the tissue covering them, may appear as faint milk-white bands. Small empty veins will not infrequently be mistaken for nerves but may be distinguished by their more superficial situation, their less direct course and the small amount of clear fluid which they usually contain, the latter being demonstrable by pressure or pinching. In certain regions the small arteries serve as guides to the nerves, as in the case of the vessels and nerves emerging through the intercostal spaces near the border of the sternum.

Failing to recognize any nerve filaments or trunks by inspection, the subcutaneous tissue may be cautiously and little by little taken up over the known course of a given nerve until the latter is reached; or an incision may be made directly down to the deep fascia parallel with the course of the nerve and search made on both sides of the cut. A nerve having been found, the tissue covering it should be dissected away from its surface in the manner detailed above for the cleaning of vessels (Fig. 3) and then from each side. When a sufficient length of the nerve

Fig. 5.—Following a nerve, the lesser internal cutaneous, a finger of the right hand making the nerve taut.

Fig. 6.—Denuding a muscle.

has thus been cleaned, it may be raised upon a finger of either the left hand (Fig. 4) or the right (Fig. 5), according to the convenience of the dissector. The tension thus produced shows clearly the further course of the nerve as well as the giving off of its branches.

The Dissection of Muscles.—When a group of muscles is exposed, it is well to effect the separation of the individual members of the group by running a scalpel handle or blunt dissector along the lines of the intervals—the latter being plainly recognizable usually—with care

Fig. 7.—Denuding a muscle.

to avoid injury to the vessels and nerves that may be found in such intervals. That a muscle may be successfully dissected it is essential that it be made tense. To attain this end the position of the limb or other portion of the body concerned must be so adjusted as to separate more remotely the points of attachment of the muscle. The connective tissue sheath of muscles is usually quite closely adherent, in some cases, as in that of the great pectoral and the oblique and transverse muscles of the abdomen, notably so. Frequent moistening of the surface is of the greatest assistance in denuding the muscle. The sheath of the muscle should be removed as a flap as nearly as possible, not with the view of preserving the flap but because the denudation is effected more easily in this way. The knife-cuts should be made in the direction of the

muscle-fibres, the blade of the scalpel being held in a plane approximately parallel with the surface of the muscle as in Figs. 6 and 7. While divesting a muscle of its connective tissue covering, a watch should be maintained for its nerve. Each muscle should be thoroughly cleaned from its origin to its insertion and should be separated from neighboring structures that it may be lifted up and satisfactorily demonstrated.

In addition to the instruments contained in the ordinary dissecting case and those usually to be found in the dissecting-room, a hypodermic syringe of ordinary size and another of rather large size will be found almost indispensable. Push-pins, to be procured from any stationer, are also very useful.

Further and more specific directions as to the dissection of the larger nerves and vessels, of bursal sacs and joints, of the special sense organs and the viscera will be found in various parts of the text as they may be required. The importance of avoiding undue haste in dissection must be emphasized, since it is only by taking infinite pains that satisfactory work can be accomplished.

CHAPTER I

THE UPPER LIMB.

THE dissection of the upper extremity includes the dissection of the anterior surface of the chest wall, of the posterior aspect of the shoulder and of the superficial structures of the back. It will usually be found desirable to begin with the dissection of the back.

Before undertaking the dissection, let the dissector review the salient features of the bones concerned. Referring to the articulated skeleton, he will note the posterior part of the **occipital** bone and its relation to the spinal column. The **vertebral column** with its **spinous processes** of varying size and degree of obliquity in the cervical, thoracic, lumbar and sacral regions, and the articulation of the **thoracic transverse processes** with the tubercles of the ribs should receive due attention. The **ribs** articulating by their heads with the bodies of the thoracic vertebræ and by their tubercles with the transverse processes, their gradual increase in size from the first and twelfth to the seventh and the variations in direction are equally noteworthy.

The **scapula** (Fig. 8) should be briefly reviewed, the **superior** (medial), **lateral** or **anterior,** and the **inferior angles,** the **vertebral, axillary** and **superior borders** being noted. On the **dorsal aspect,** the **spine** and its **acromion process,** the **supra-** and **infraspinous fossæ** claim attention, while on the **ventral surface** (Fig. 9) one finds the **venter** or **subscapular fossa.** At the outer angle is the **glenoid cavity** and springing from the upper part of the **neck**—the constriction of which the **suprascapular** notch is a part—is the **coracoid process.**

THE BACK.

THE SURFACE ANATOMY.

The study of the surface markings of any region should precede the dissection of that region. For this purpose one may utilize the cadaver but the living subject is preferable since, in the latter case, the surface markings are more conspicuous and therefore more easily recognizable.

On the back of the head, at the upper limit of the back, in the midline, one may feel the **external occipital protuberance** of the occipital bone. Passing downward from this prominence is a mesial furrow, in which, immediately below the prominence, the rudimentary **spinous process of the atlas** may be felt by deep pressure. The **spinous processes** of the succeeding cervical vertebræ, except that of the seventh, are not

easily recognizable individually, but may be felt as a more or less continuous ridge.

The **spine of the seventh cervical vertebra,** *the vertebra prominens,* is quite conspicuous, and the **spine of the first dorsal vertebra,** just below it, is even more so. The spines of the remaining dorsal vertebræ, as well

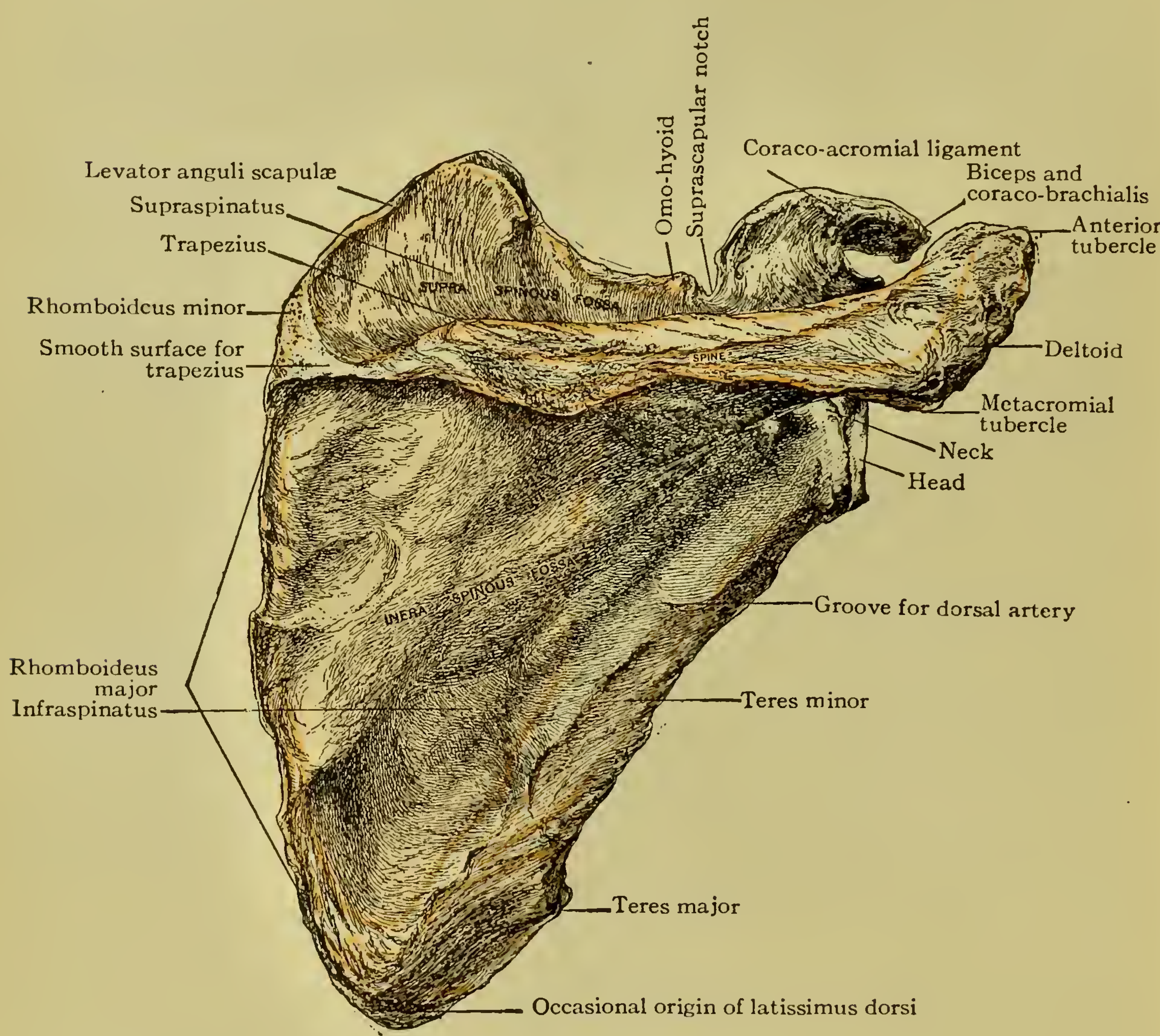

FIG. 8.—Dorsal surface of right scapula.

as those of the lumbar vertebræ, may be followed in succession, their line however not being absolutely mesial, but presenting more or less deviation to one or other side. In the lower dorsal and lumbar regions, these prominences lie in a mesial furrow which is bounded on either side by the rounded eminence of the erector spinæ muscle. Below the limits of the lumbar region of the spine, one encounters the rough and uneven **posterior surface of the sacrum,** diverging from which, on either side, is the **crest of the ilium,** easily followed from its **posterior superior spinous**

process to its **anterior superior spine.** It should be noted that the posterior superior spine of the ilium—indicated by a dimple—is on the level of the second sacral spine, and that the highest point of the crest of the ilium is level with the fourth lumbar spine.

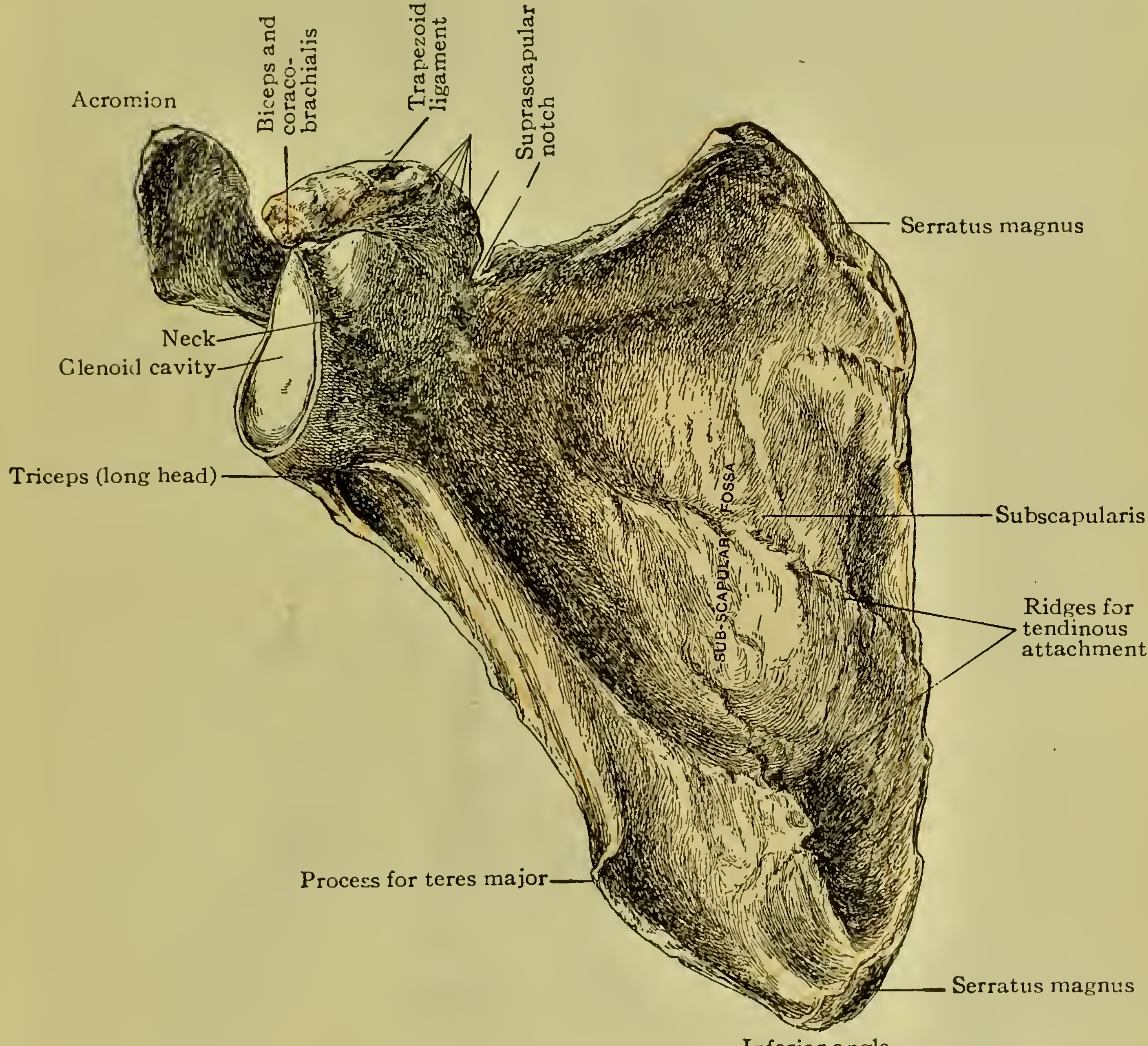

FIG. 9.—Right scapula from below.

The **ribs** and the **intercostal spaces** may be more or less clearly made out by palpation as ridges and intervening depressions extending obliquely downward and outward from the spine.

The **scapula** may also be recognized by palpation throughout a portion of its extent. Its position varies with the movements of the arm; with the arm hanging passively by the side, the superior angle of the scapula is at the second intercostal space or as high as the upper border of the second rib, its inferior angle being opposite the seventh

or eighth rib. The scapula is somewhat difficult to palpate in its entirety especially in subjects of good muscular development.

DISSECTION.

The cadaver should be supported by blocks under the pelvis and the upper part of the chest respectively, since the tension of the skin and muscles thus produced facilitates the dissection.

Removal of the Skin.—Make a median incision from the occiput to the tip of the coccyx (Fig. 10); a second, curved, incision along the

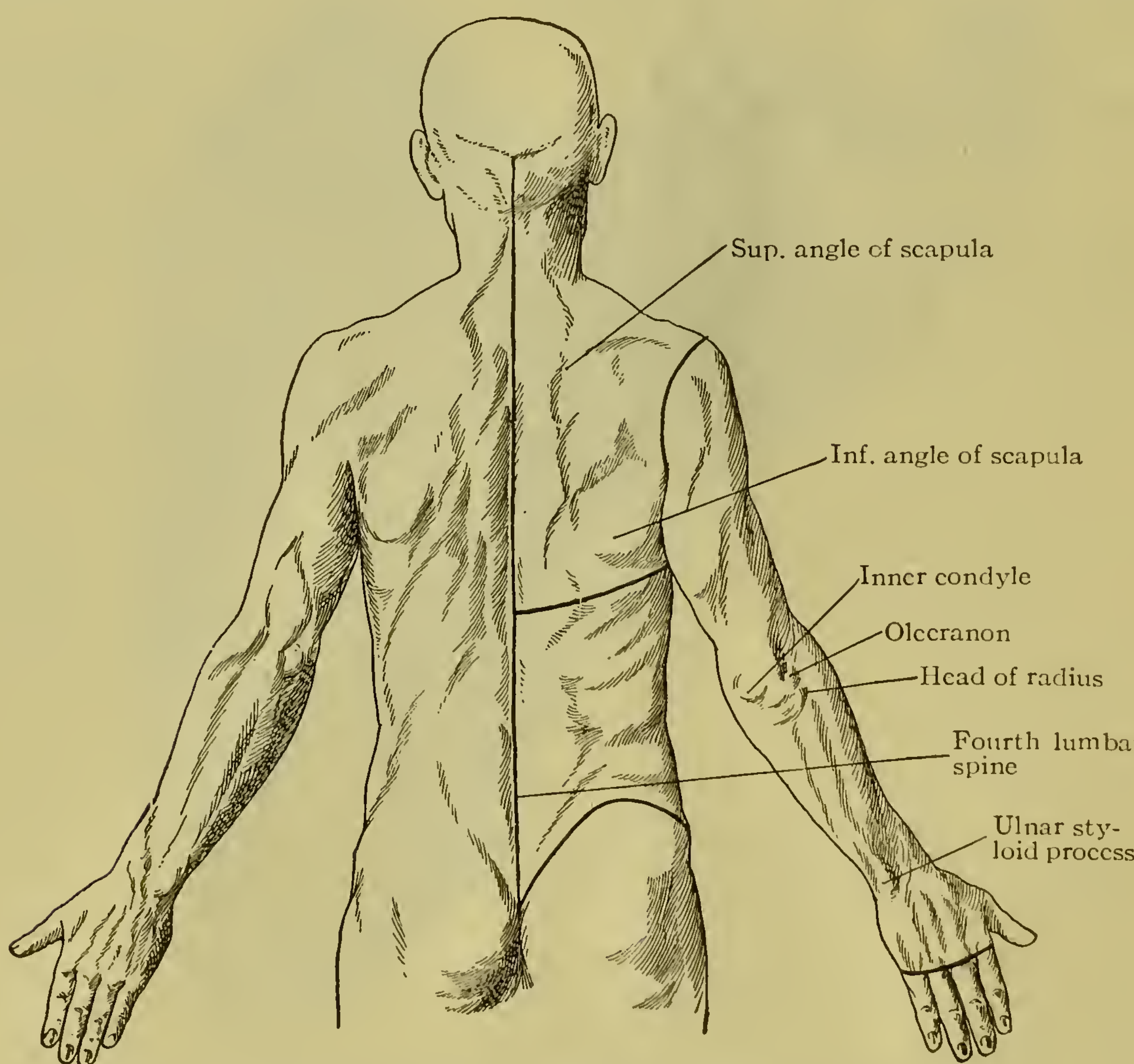

Fig. 10.—Surface anatomy of back, showing lines of incision.

crest of the ilium; a third from the 12th dorsal spinous process to the posterior axillary line, a few inches below the junction of the arm with the trunk; a fourth from the upper end of the median incision, transversely outward for a distance of three inches; a fifth from the outer extremity of the last incision to the acromion process of the scapula; to these may be added a curved incision over the posterior aspect of the shoulder. Allowing the arm to hang over the edge of the table, begin at the mid-line, at the upper corner of the lower flap, to remove the skin.

In doing so, hold the corner of the skin-flap with toothed forceps and, later, with the fingers, making considerable tension. Keep the plane of the knife-blade approximately parallel with the plane of the under surface of the flap, cutting always close to the skin so as to remove none of the underlying superficial fascia. The upper flap may now be removed, the arm being allowed to hang over the edge of the table or being drawn downward as may be required at different stages of the dissection. Inasmuch, however, as the skin affords the best protection against evaporation of moisture and the consequent drying of the tissue, it is better to defer the removal of the upper flap until the region exposed by the removal of the lower one shall have been completed.

The Superficial Fascia.—The superficial fascia here, as elsewhere, contains more or less fat according to the condition of the individual subject. Usually it will be found infiltrated with fluid, especially if the subject has been allowed to lie on the back for some time previous to dissection. The presence of this fluid in any considerable quantity renders the search for the cutaneous nerves and vessels which ramify in this fascia rather more difficult. The superficial fascia of the back is directly continuous with that of adjacent regions and presents no especially noteworthy features, except that it is thicker than in many other parts of the body, the better to cushion the numerous bony prominences found here.

The **superficial arteries** are small and of no particular importance; they are branches of the dorsal divisions of the intercostal and lumbar arteries of the aorta.

The **superficial nerves** are cutaneous branches of the spinal nerves (Fig. 11). In the cervical and dorsal regions they become superficial close to the vertebral spinous processes; in the lumbar region they emerge through the muscles and deep fascia at points from one to six inches distant from the spinous processes. It should be noted that the position of a given nerve does not correspond with that of the vertebra of corresponding number, the nerve, before it pierces the muscles and deep fascia, taking a downward course to emerge on a level with the first or second vertebra below. Moreover, these nerves are subject to some irregularity as to course and relative size, some of the series being occasionally absent, especially in the cervical region. In searching for them, it is well to begin at the mid-line to remove the superficial fascia, working outwardly until they are found as they emerge through the deep fascia. Once a portion of a cutaneous nerve-trunk is found, it is comparatively easy to trace it to its termination. This is best done by picking up the fatty tissue which covers it and dissecting it off, after which the nerve may be raised, first upon the forceps and then upon a finger, the slight tension thus produced rendering its further course evident. The presence of a considerable quantity of fluid in the subcutaneous tissue of the

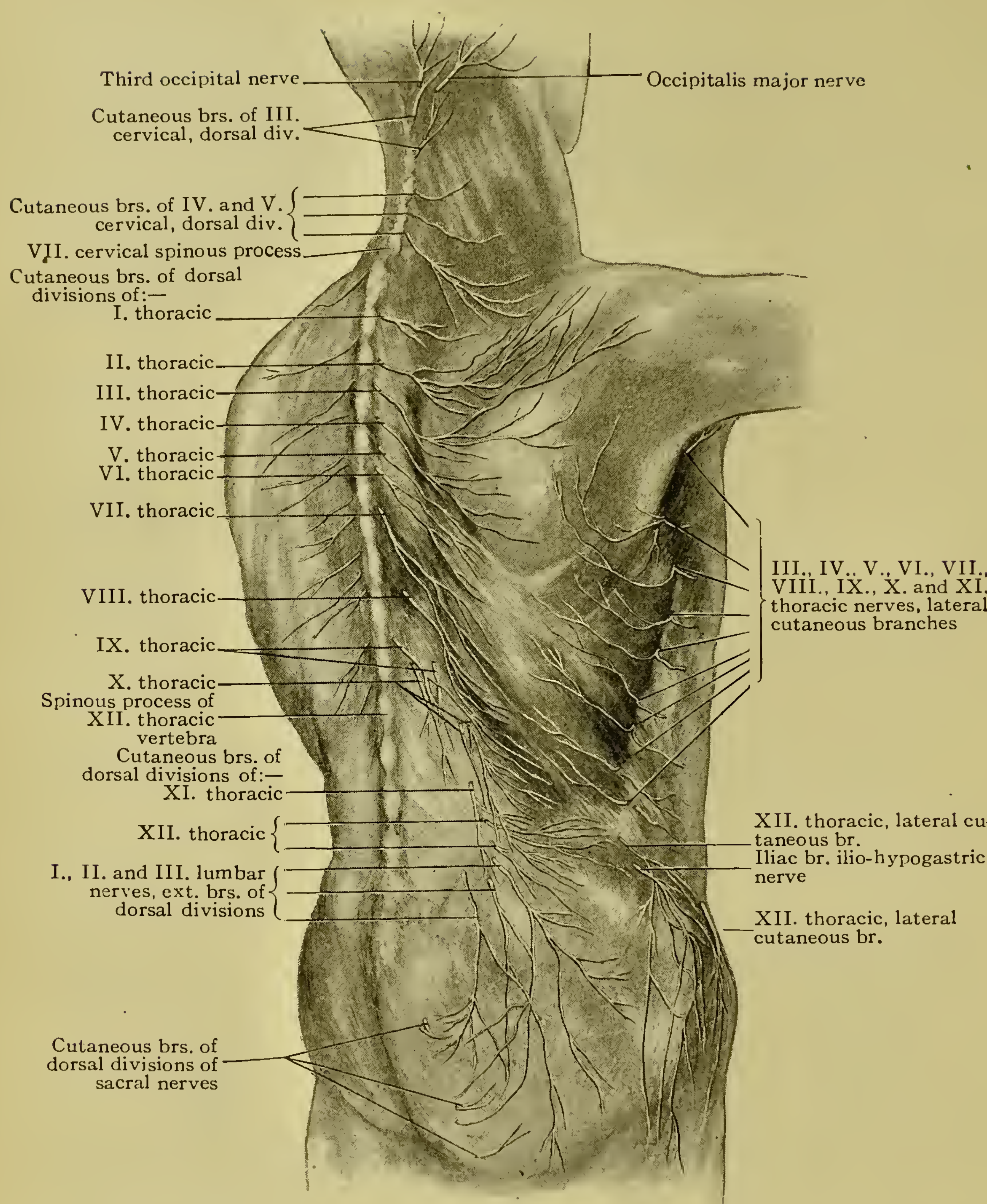

FIG. 11.—Superficial dissection, showing cutaneous branches of posterior divisions and lateral cutaneous branches of anterior divisions of spinal nerves.

back increases the difficulty of discovering the cutaneous nerves. This feature may be obviated by allowing some little time for evaporation of the fluid, or by repeatedly pressing firmly against the surface of the tissue a pad of dry or tightly wrung-out cheese-cloth.

In order to appreciate the relative importance of the cutaneous nerves of the back, it will be necessary to take note of the scheme of a typical spinal nerve as shown in Fig. 12, reference to which discloses the fact that these cutaneous nerves of the back are the cutaneous branches of the posterior divisions of the spinal nerves. Typically, each posterior division divides into two branches, one which is chiefly cutaneous in its distribution and one which is entirely muscular. In the case of the cervical nerves, except the first, and the upper six thoracic nerves, the internal branch of the posterior division is cutaneous and the external

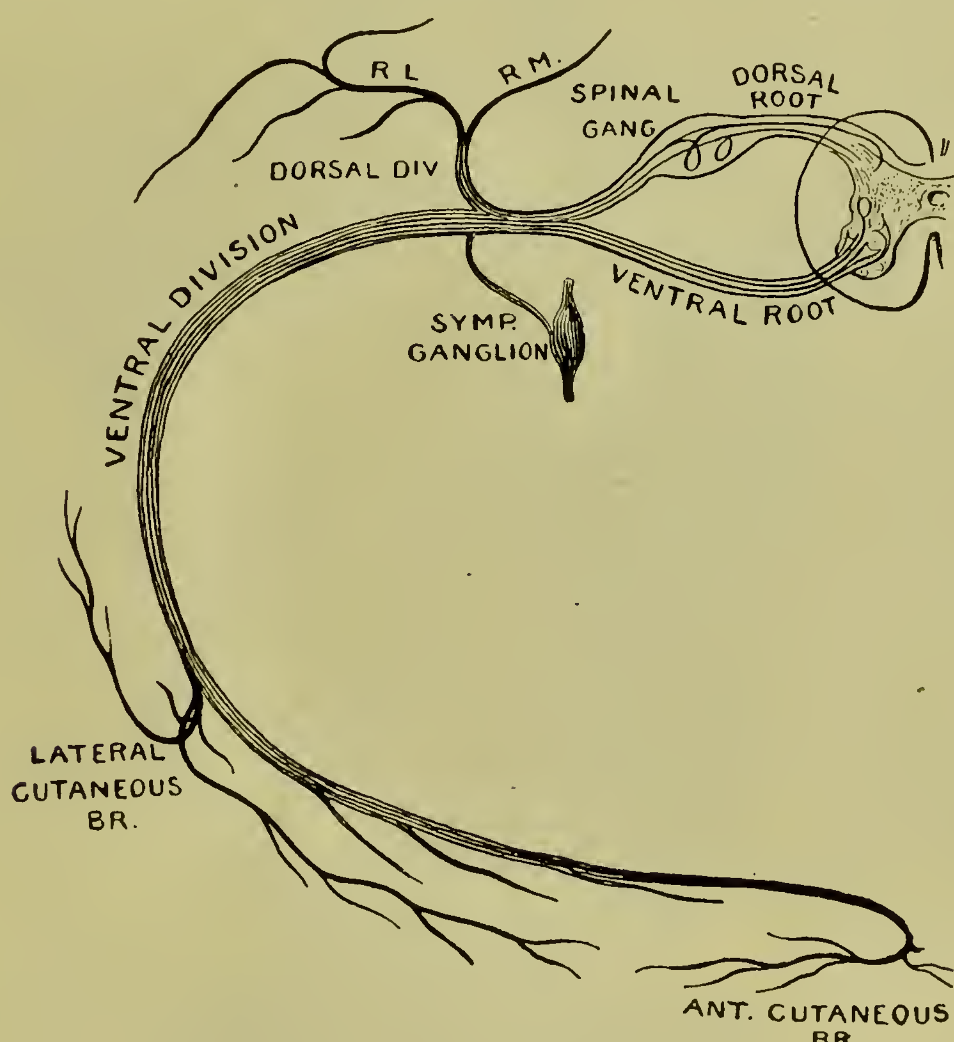

FIG. 12.—Scheme of a spinal nerve.

one is muscular; while in the lower six thoracic, the lumbar and the sacral nerves, the reverse condition obtains.

Beginning the search for the nerves at the upper part of the dissection, the **occipitalis major** will be found either piercing the trapezius near its outer border and close to its attachment to the superior curved line of the occipital bone in company with the occipital artery, or piercing the deep fascia just external to the border of the trapezius. As this nerve passes up to supply the scalp, its further dissection does not concern the dissector of the back. The occipitalis major is the internal cutaneous branch of the posterior division of the second cervical nerve,

being larger than any of the other posterior cervical divisions. Though usually of conspicuously large size, the occipitalis major is sometimes smaller, being partly replaced by an unusually large occipitalis minor. In the immediate vicinity of the great occipital nerve will sometimes be found a cutaneous filament from the **suboccipital** or first cervical **nerve,** the posterior division of which differs from the other cervical nerves in not dividing into an internal and an external branch.

The **third occipital nerve,** the internal cutaneous branch of the third cervical posterior division, pierces the trapezius and the fascia below and to the inner side of the great occipital nerve, with which it communicates, and passes upward to supply the back part of the scalp.

The **cutaneous branch** of the dorsal division of the fourth cervical nerve may be quite small or entirely absent; the same may be said of the **sixth, seventh** and **eighth dorsal cutaneous nerves.**

The **dorsal cutaneous branches** of the **thoracic nerves** are fairly constant and have a more extensive distribution than the corresponding cervical nerves; they become more oblique in direction in the lower part of the thoracic region, the dorsal cutaneous branch of the twelfth thoracic becoming superficial just above the crest of the ilium and being distributed to the skin of the upper part of the gluteal region.

The **lateral cutaneous** branches of the dorsal or intercostal nerves (Fig. 11) pierce the deep fascia in the axillary line, their dorsal divisions being distributed to the skin of the back, while their ventral branches pass forward to the lateral and ventral aspects of the trunk.

The **lateral cutaneous** branch of the twelfth thoracic nerve is especially well developed and passes downward and forward over the crest of the ilium to aid in supplying the skin of the gluteal region (Fig. 11).

The Deep Fascia.—The deep fascia of the back forms an investment for the muscles and is more aponeurotic in character than the superficial fascia, from which it further differs in not being the seat of fatty deposit. It is attached to the vertebral spinous processes mesially, to the superior curved line of the occipital bone above, and to the crest of the ilium below. It is continuous laterally, in the cervical region, with the deep cervical fascia, becomes attached to the spine of the scapula and its acromion process in the scapular region, and below the shoulder is continuous with the axillary fascia and the deep fascia of the lateral and ventral aspects of the body-wall. Upon the removal of the deep fascia the superficial layer of the muscles of the back will be exposed (Fig. 13).

The Trapezius Muscle.—**Origin,** the superior nuchal line and the external protuberance of the occipital bone, the ligamentum nuchæ, the spinous process of the seventh cervical vertebra, the spinous processes of all the thoracic vertebræ and the supraspinous ligaments. **Insertion,** the outer third of the posterior border of the clavicle, the

tubercle at the base of the spine of the scapula, the upper border of the spine of the scapula and the upper surface and inner border of its acromion process. **Nerve-supply,** from the spinal accessory and the third and fourth cervical nerves, which pass under the anterior border of the

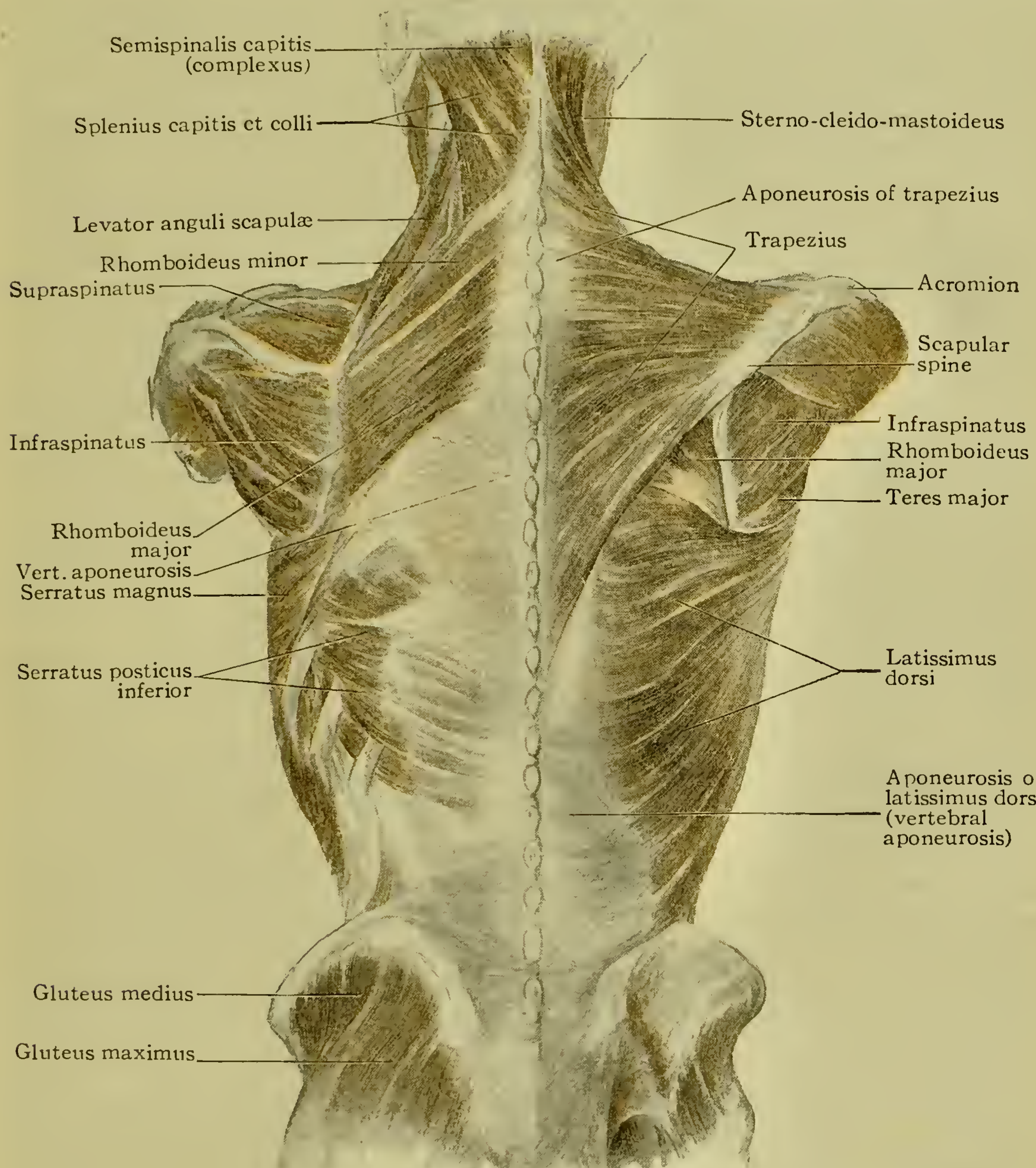

FIG. 13.—Superficial muscles of the back.

muscle to enter its deep surface. **Action,** to elevate the shoulder, or, if the shoulder is fixed, to extend the head; to pull back and to rotate the scapula (Fig. 13).

The dissection of the muscle may be facilitated by flexing the head and drawing down the shoulder to make the upper part of the muscle

tense. The removal of the deep fascia should be begun at the occipital attachment of the muscle, the dissector working downward and outward in the direction of the muscular fibres. The upper part of the trapezius is sometimes poorly developed, in which case its dissection is difficult, and the difficulty is greatly increased if there be much infiltration of the overlying fascia; in such case it is better to begin the cleaning up of the muscle near the lower cervical spinous processes, working outward until the outer edge of the muscle is reached, when this outer edge may then be more easily followed up to its occipital attachment. In order to avoid the damaging of structures which belong to the dissection of the neck, do not carry the dissection beyond the outer edge of the muscle. In denuding the lower part of the muscle, shove the shoulder outward and upward, removing the fascia again in the direction of the muscular fibres and, as much as possible, as a layer or flap, since it is easier to get the surface clean thus than by removing the fascia piecemeal.

The muscle having been thoroughly cleaned from its origin to its insertion, note its shape, its tendinous aponeurosis, its points of origin and insertion and its relation to the latissimus dorsi. Note also its action upon the shoulder.

The trapezius may be at fault in *wry-neck* or *torticollis*, assisting the sterno-cleido-mastoid in producing the deformity (see p. 352).

THE LATISSIMUS DORSI.—**Origin,** the spines of the lower six thoracic vertebræ (tendinous fibres) and the corresponding interspinous ligaments; the lumbo-dorsal fascia (and hence from the lumbar and sacral spinous processes); the crest of the ilium (the back part of its outer lip); by fleshy fibres from the three or four lower ribs and, occasionally, from the inferior angle of the scapula. **Insertion,** crest of inner tuberosity of the humerus or bottom of bicipital groove, in close association with the tendon of the teres major. **Nerve-supply,** from the seventh and eighth cervical nerves, through the long subscapular nerve, which enters the ventral surface of the muscle at some point below the middle of the axillary space. **Action,** to draw the humerus downward, backward and inward while rotating it inward; or, if the arm be fixed, to draw the trunk upward, as in climbing (Fig. 13).

To make the muscle tense, as an aid to its dissection, carry the arm well up toward the head. The dissection may be begun over the fleshy part of the muscle, the denudation being carried from the point of starting toward each extremity. By following this method the dissector will find it easier to avoid mutilating the aponeurosis of origin, this aponeurosis sustaining such an intimate relation to the overlying connective tissue that its recognition is often quite difficult.

For *variations* in this muscle, see p. 41. For the relation of the muscle to the external oblique of the abdomen and Petit's triangle, see p. 601.

When the latissimus dorsi has no attachment to the inferior angle of the scapula, the edge of the muscle overlaps this angle of the bone. This relation may be disturbed by violence, constituting *dislocation of the inferior angle of the scapula.*

The student should note the aponeurotic portion of the origin of the muscle, *i.e.*, that portion which arises from the lumbar and sacral spines, and the relation of this aponeurosis to a layer of fascia which incloses the deeper muscles of the back. The aponeurosis of the latissimus is, in fact, the posterior aponeurosis of the lumbar fascia. (See p. 581.) Note also the relation of the upper border of the muscle to the inferior angle of the scapula, and the association of its insertion with the teres major.

Now remove the trapezius in part by detaching it from the spine of the scapula and from the outer part of the clavicle, and reflect the detached portion toward the spinal origin of the muscle. A part of the clavicular attachment should be left undisturbed in order not to interfere with the dissection of the triangles of the neck.

The reflection of the trapezius should be effected with such care as not to disturb the vessels and nerves beneath it; a few light touches with the knife, close to the under surface of the muscle, may be required to free it. Several arteries will be found in close relation with its deep surface; one, the superficial cervical, a terminal branch of the transversalis colli, is near the upper anterior border of the muscle, pursuing its course upward; another, a muscular branch of the posterior scapular, enters the deep surface of the muscle about opposite the middle of the scapula.

The **bursa** which lies between the muscle and the triangular smooth area at the base of the spine of the scapula should be noted; its cavity may be demonstrated either by injection of air or fluid, or by inserting a finger through an incision in its wall. The removal of the trapezius exposes to view the levator anguli scapulæ, and the rhomboideus major and minor.

THE LEVATOR ANGULI SCAPULÆ.—**Origin,** the transverse processes of the upper four cervical vertebræ, tendinously; **insertion,** the vertebral border of the scapula from the mesial (superior) angle to the triangular smooth area at the root of the spine; **nerve-supply,** the fifth cervical nerve through the dorsal scapular nerve (the nerve to the rhomboids); **action,** to elevate the mesial angle of the scapula, thereby depressing the shoulder; to aid the trapezius in elevating the shoulder; to aid the trapezius and the rhomboids in antagonizing the serratus anterior to produce fixation of the scapula for the action of the scapulo-humeral muscles (Fig. 13).

The surface of the muscle should be cleared of connective tissue and its attachments noted. It should not be further disturbed at this stage of the dissection, its ventral surface especially being left intact since this pertains to the occipital triangle of the neck.

The Rhomboideus Minor.—**Origin,** the spinous processes of the first thoracic and seventh cervical vertebræ and the adjacent part of the ligamentum nuchæ; **insertion,** the vertebral border of the scapula opposite the base of its spine; **nerve-supply,** the fifth cervical nerve, anterior division; **action,** to draw the scapula upward and toward the spine, the lateral (external) angle being at the same time depressed.

This is a flat muscle of rather delicate texture; hence care must be exercised in cleaning it, it being especially important to make its fibres tense by pulling the scapula downward and outward (Fig. 13).

The Rhomboideus Major.—**Origin,** by tendinous fibres from the spinous processes of the upper four or five thoracic vertebræ and the supraspinous ligaments; **insertion,** the vertebral border of the scapula from the base of its spine to the inferior angle. Usually the attachment of the muscle to the scapula is by means of a curved tendinous band in which the muscle-fibres terminate, the two extremities of the band being attached directly to the scapula while the intervening concave outer border is connected with the scapula by a thin membrane. **Nerve-supply,** the fifth cervical nerve, anterior division. **Action,** to draw the scapula backward and upward, and especially to elevate the inferior angle and so depress the outer angle (Fig. 13).

Variations.—Sometimes both rhomboids are absent; occasionally they are blended, forming practically one continuous muscle.

Having completed now the dissection of this group of muscles, *i.e.*, the latissimus dorsi, the trapezius, the levator anguli scapulæ and the rhomboidei, the student should note that the latissimus directly connects the trunk with the upper arm by reason of its insertion into the humerus, while the other four muscles connect the spinal column with the shoulder-girdle, namely, the scapula and the clavicle. It should be noted also that the levator anguli scapulæ and rhomboidei, if acting without the co-operation of the trapezius, tend to rotate the scapula, elevating its superior (medial) angle while depressing its lateral (outer) angle; and that this action may be aided by the lower fibres of the trapezius, while if the upper fibres of this muscle act with the rhomboids and the scapular elevator, the entire shoulder is elevated. Possibly the most important function of this vertebro-scapular group of muscles is, by antagonizing the serratus magnus muscle, to steady the scapula and thereby to afford to the scapulo-humeral muscles a fixed point or fulcrum from which to act upon the humerus.

The Posterior Scapular Artery.—This vessel is either one of the terminal branches of the transversalis colli artery, arising from that vessel after it has crossed the upper posterior triangle of the neck and passed under the edge of the trapezius (Fig. 14); or it arises directly from the third portion of the subclavian artery, passing outward through the subclavian triangle and then across the occipital triangle to pass

under the trapezius. It then goes beneath the elevator of the angle of the scapula to the superior (medial) angle of the scapula (Fig. 15); thence downward along the vertebral border of the bone under the rhomboid muscles close to their insertion to a point at or near its inferior angle. To expose the artery, search for it along the outer border of the levator anguli scapulæ where it may be found readily. In freeing the vessel of connective tissue, one should have regard for the dorsal scap-

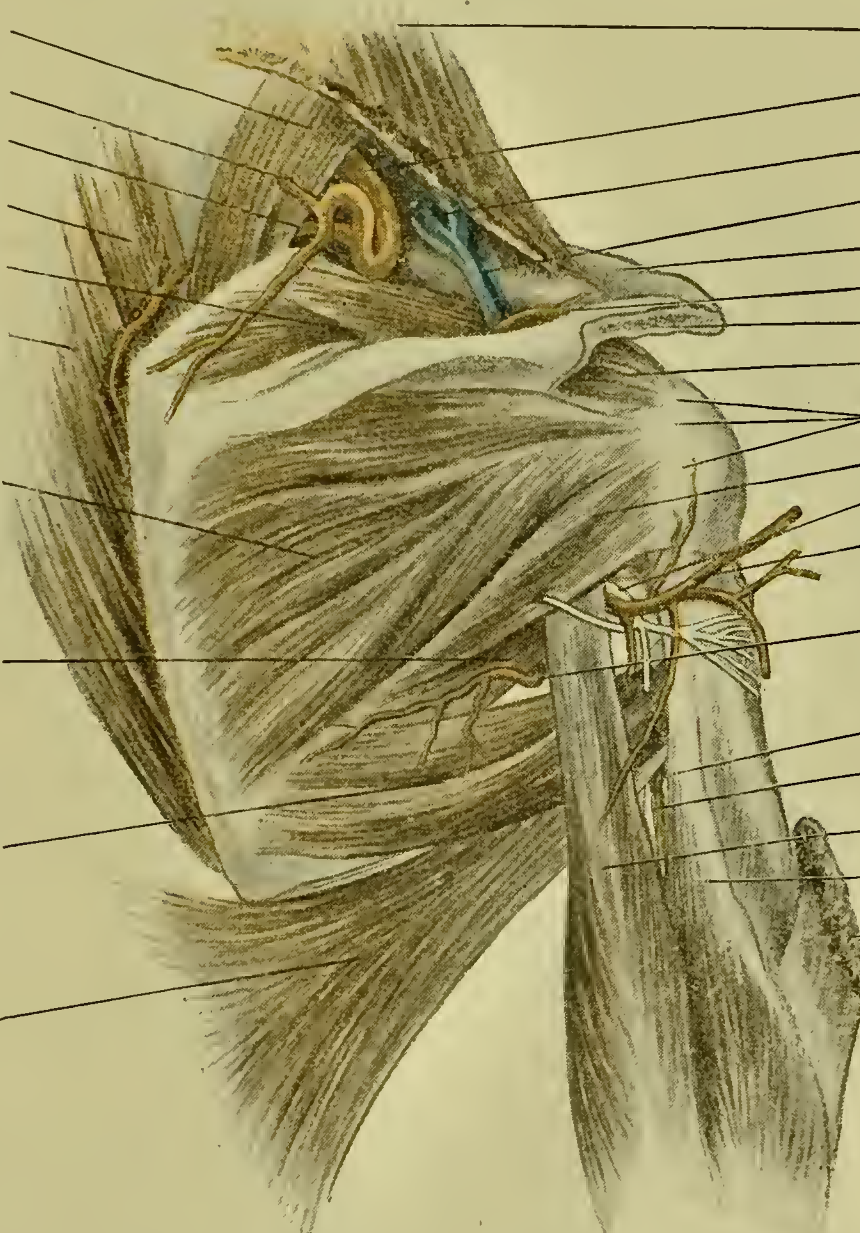

FIG. 14.—Dissection of dorsal aspect of shoulder.

ular nerve, the nerve supply of the rhomboids, which lies to the inner side of the artery. Trace the artery first toward its origin, and having determined this, trace it distally, for this purpose incising the levator anguli scapulæ and the rhomboids close to their scapular attachments. In tracing the artery downward, note the giving off of **branches** to both the ventral and the dorsal aspects of the scapula,—among the latter being the *supraspinal* branch to the supraspinatus,—the emergence of a rather large branch through the smaller or larger rhomboid or

between the two rhomboids to enter the deep surface of the trapezius, and the very free *anastomosis* formed by the terminal branches of this vessel on the lower part of the dorsal surface of the scapula, chiefly between the infraspinatus and the bone, with the dorsalis scapulæ from the subscapular artery.

The **dorsal scapular nerve,** or posterior scapular nerve, the nerve to the rhomboids (Fig. 15), will be found passing under the outer border of the elevator of the angle of the scapula, to the inner side of the posterior scapular artery. Tracing it upward it will be found to emerge from the outer aspect of the scalenus medius, which muscle it

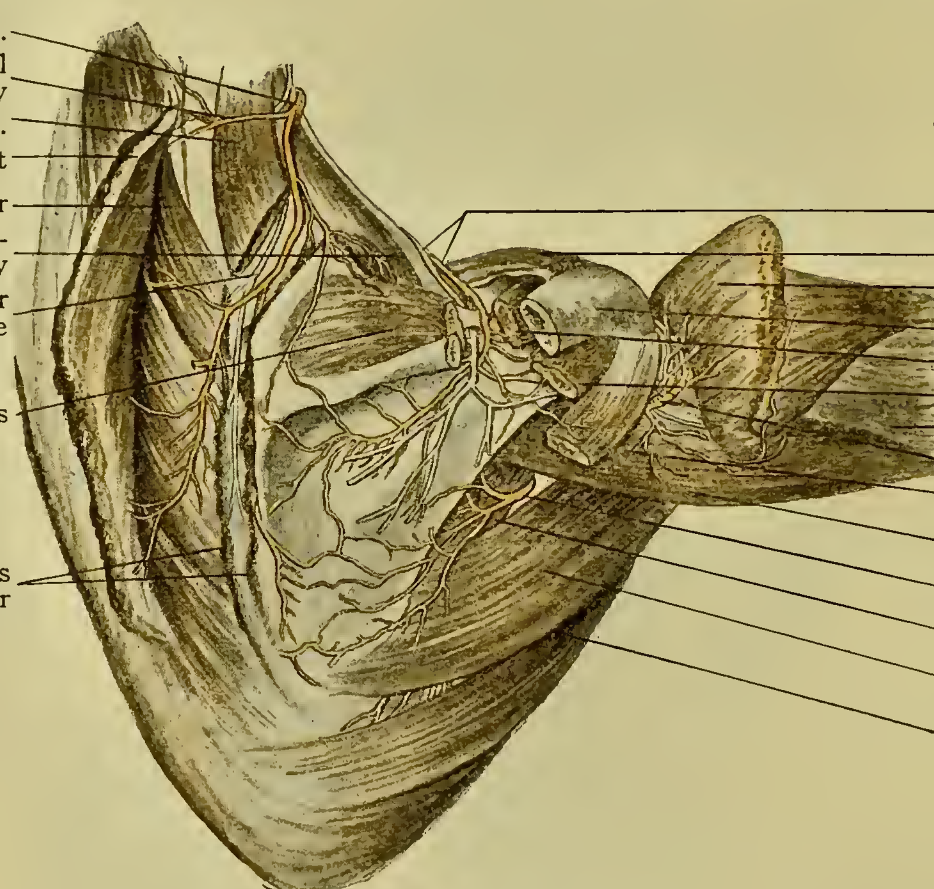

FIG. 15.—Vessels and nerves of posterior aspect of shoulder.

pierces, and traced still further, it may be seen to be a branch of the ventral division of the fifth cervical nerve. Followed beneath the levator anguli scapulæ it will be found usually to give some filaments to this muscle, and then to pass on to be distributed to the deep surfaces of the rhomboids.

Having completed the dissection to this point, the dissector may proceed with the dissection of the scapular muscles and associated structures, or he may defer this work until after the detachment of the upper extremity from the trunk. If the latter course be chosen, he should at least, at this stage, dissect partially the suprascapular artery and nerve, as indicated on page 24, before such disturbance of the relations of parts occurs as necessarily ensues upon disarticulation. From the standpoint of a better preservation of the relations of structures, it will be

much more advantageous to complete the dissection of the posterior scapular region before disarticulation.

The Supraspinous Fossa.—The supraspinous fossa (Fig. 8), that part of the dorsal surface of the scapula above the spine, is occupied by the supraspinatus muscle and the suprascapular artery and nerve, these structures being covered by the **supraspinatus fascia,** a rather dense membrane attached to the edges of the fossa except externally, where it thins out upon the tendon of the supraspinatus muscle. The fascia may be demonstrated readily by clearing the loose connective tissue from its surface. In doing this, inspect the outer part of the fossa, that is, the part underlying the acromion process, for the **subacromial bursa,** which lies upon the supraspinatus muscle and tendon and beneath the acromion process and the coraco-acromial ligament. The bursa may be demonstrated by inserting a finger or a director through an incision in its wall, or by the injection of air or fluid. It is sometimes in communication with the subdeltoid bursa (p. 58) and may then appear to be merely a part of that sac; it is perhaps on this account that the terms *subacromial bursa* and *subdeltoid bursa* are often used interchangeably.

As a preliminary to the dissection of the posterior scapular muscles, the deltoid muscle (Fig. 31) may be partially dissected and displaced forwards. That portion of the deltoid which takes origin from the spine of the scapula and its acromion process may be cleaned by removing the dense, closely adherent **deltoid fascia** which covers it. In and upon this fascia ramify some cutaneous nerves, branches of the circumflex nerve, some of which perforate the muscle to reach its surface, while others wind around its posterior border (Fig. 46). Having isolated the nerves, cautiously raise the posterior border of the muscle, and displace it forward—the arm being elevated—separating the deep surface of the muscle from the parts beneath with the handle of a scalpel or a blunt dissector, and exercising extreme care in order not to wound or tear the nerves and vessels encountered here, branches of which enter the deep surface of the muscle. The nerves and vessels are usually masked by a considerable quantity of fat and cellular tissue. They may or may not be completely dissected at this stage. To facilitate the forward displacement of the deltoid, the posterior third of the muscle may be divided near its origin, the edges of the incision being subsequently sutured if thought desirable, to restore the normal relations of parts.

The Supraspinatus Muscle.—**Origin,** the inner two thirds of the supraspinous fossa and the deep surface of the supraspinatus fascia (Fig. 14); **insertion,** the upper facet of the great tuberosity of the humerus (Fig. 37); **nerve-supply,** through the suprascapular nerve from the fifth and sixth cervical nerves; **action,** to abduct the arm.

To display this muscle to the best advantage, it is necessary to remove a portion of the scapular spine and of the acromion process with

the saw (Fig. 15). The muscle may now be followed to its insertion, the close relation of its tendon to the capsule of the shoulder-joint being noted, as also the connection of this tendon with the infraspinatus tendon. An infrequent *variation* is the presence of a slip passing from the tendon of the supraspinatus to the tendon of the great pectoral and the outer bicipital ridge of the humerus.

The Suprascapular Artery (transversalis humeri, transversa scapulæ).—The **origin** of this vessel is the thyroid axis of the subclavian (Fig. 185); its course is downward and outward beneath the sterno-mastoid muscle, then outward beneath the clavicle to the outer angle of the subclavian triangle, and then beneath the omo-hyoid muscle to reach its outer side close to its scapular origin. Arriving thus at the suprascapular notch, it passes over the ligament which bridges that notch (Fig. 33) to reach the supraspinous fossa in company with the suprascapular nerve, the latter structure passing under the ligament. The supraspinatus muscle should now be incised in a direction downward and somewhat outward, that the artery and nerve may be traced in their course between the muscle and the bone to the great scapular notch between the root of the scapular spine and the glenoid cavity—the neck of the scapula. Passing under the spino-glenoid ligament the vessel and nerve now enter the infraspinous fossa (Fig. 15), where they break up into terminal branches which enter the deep surface of the infraspinatus muscle; the dissection of these branches should be deferred until after the dissection of the infraspinatus.

The **branches** of this vessel are the *suprasternal*, near its origin, passing superficially to the suprasternal region of the chest wall; the *inferior sterno-mastoid* and *muscular* branches; a *nutrient artery* to the clavicle; an *articular* branch to the acromio-clavicular joint; the *supra-acromial*, which pierces the trapezius to reach the acromial region of the shoulder, where it anastomoses with branches of the acromial thoracic; the *subscapular*, which arises close to the superior border of the scapula and is distributed to the subscapularis muscle; *muscular* branches to the supraspinatus; an *articular* branch to the shoulder-joint, arising as the parent trunk passes across the neck of the scapula to the infraspinous fossa; *muscular* branches to the infraspinatus.

The Suprascapular Nerve.—If this nerve be picked up with forceps at the upper border of the scapula it may be traced toward its **origin,** the upper trunk of the brachial plexus—a trunk formed by the union of the fifth and sixth cervical nerves. Leaving the subclavian triangle—its usual place of origin—by passing outward under the omo-hyoid muscle, it reaches the upper border of the scapula and traverses the foramen formed by the transverse or suprascapular ligament bridging over the suprascapular notch. Entering the supraspinous fossa with the suprascapular artery it runs in company with that vessel, beneath the super-

spinatus and around the outer extremity of the spine of the scapula to the infraspinous fossa (Fig. 15), where it breaks up into branches which enter the deep surface of the infraspinatus muscle. Its **branches** are two *muscular* twigs to the supraspinatus, which enter the deep surface of the muscle; an *articular* branch to the shoulder-joint, which arises near the outer extremity of the spine of the scapula, and two *muscular branches* to the infraspinatus (Fig. 15).

The Infraspinous Fossa.—This fossa is that part of the dorsal surface of the scapula which is below the spine (Fig. 8). It is occupied by the infraspinatus muscle and the terminal portions of the suprascapular artery and nerve, and of the posterior scapular and the dorsalis scapulæ arteries. The muscle is covered with the **infraspinatus fascia,** a membrane of considerable deneness, which is attached above to the scapular spine and mesially to the vertebral border of the scapula, while laterally it becomes continuous, in attenuated form, with the deep fascia of the arm. Where the posterior border of the deltoid muscle overlaps the infraspinatus, the fascia splits into two layers, the superficial stratum passing upon the surface of the deltoid as the deltoid fascia, the deep layer continuing outward and upward upon the tendon of the infraspinatus muscle to the capsule of the shoulder-joint. The removal of this fascia, which should now be effected, exposes the infraspinatus muscle. In removing the fascia, the dissector should guard against mutilating the arteries which cross the vertebral border of the scapula to ramify beneath the muscle as well as those to be found in the interval between the infraspinatus and the teres minor (Fig. 15).

THE INFRASPINATUS MUSCLE (Fig. 14).—**Origin,** the inner two thirds of the infraspinous fossa, the infraspinatus fascia, and the fascia between this muscle and the teres minor; **insertion,** the middle facet of the great tuberosity of the humerus; **nerve-supply,** the fifth and sixth cervical nerves through the suprascapular. **Action,** outward rotation of the humerus; to pull the humerus backward when in the abducted position or after it has been drawn forward in the horizontal or approximately horizontal plane. **Variations:** sometimes inseparably blended with the teres minor; sometimes divided into upper and lower portions.

The tendon of this muscle glides over a smooth surface of bone immediately external to the scapular spine and as it crosses the capsule of the shoulder-joint is frequently separated from the capsule by the **infraspinatus bursa,** which, when present, usually communicates with the joint-cavity. In denuding the muscle of its connective tissue investment, carry the arm upward toward the head in order to put this muscle, as well as the two following ones, upon the stretch. The dissection may be begun at the peripheral parts of the infraspinous fossa and carried toward the tendon of insertion.

The general form and relations of the muscle having been noted,

it may be incised near the outer extremity of the root of the scapular spine in order to trace the suprascapular artery and nerve. Aside from this incision, it will be well to preserve it intact until the teres muscles shall have been dissected.

THE TERES MINOR (Fig. 14).—**Origin,** the upper two thirds of the axillary border of the dorsal surface of the scapula and the septa between the teres minor and the infraspinatus and the teres minor and the teres major respectively; **insertion,** the humerus, the lowest facet of the greater tuberosity and the surface immediately below it; **nerve-supply,** the circumflex nerve from the fifth and sixth cervical nerves; **action,** to rotate the humerus externally; to pull the humerus backward when in the abducted position or after it has been drawn forward in the horizontal plane.

The dissector should clean the muscle from its origin to its insertion, noting the close relation of the tendon to the shoulder-joint capsule and carefully separating the muscle from the infraspinatus—which may be difficult in those cases where the two are blended—and from the teres major. In the interval between the two teres muscles some branches of the dorsalis scapulæ artery will be found and, more deeply, rather in relation with the ventral surface of the muscle, the dorsalis scapulæ itself. These vessels may be concealed by fatty and connective tissue, which should be removed by careful dissection along the respective lines of the vessels. The ventral surface should be separated from the scapular head of the triceps cautiously by blunt dissection (Fig. 14) to avoid injury of vessels and nerves. The nerve of supply to the muscle, a branch of the circumflex nerve, enters it along its outer border at some little distance from its insertion.

THE TERES MAJOR (Fig. 14).—**Origin,** the scapula, on the lower third of the axillary border of the dorsal surface; **insertion,** the humerus, upon its inner bicipital ridge (crest of the lesser tuberosity) by a flat tendon; **nerve-supply,** the lower subscapular nerve from the fifth and sixth cervical nerves; **action,** to rotate the humerus inward and to draw it toward the trunk and backward.

The teres major cannot be followed to its termination at this stage of the dissection without detriment to other structures. It should, however, be carefully separated by blunt dissection from the latissimus dorsi on its outer side to the point where both muscles pass beneath the long head of the triceps (Fig. 14).

The **dorsalis scapulæ artery,** a branch of the subscapular (p. 45), should now be sought in the interval between the two teres muscles, as it crosses the vertebral border of the scapula at about one third of the distance from the lower margin of the glenoid cavity to the inferior angle of the bone (Fig. 14). The teres minor muscle should be crowded inward to expose the vessel fully—it is undesirable to incise or remove the

muscle at present—and the artery will then be seen to traverse a triangular muscular interval (Fig. 14) which is formed by the teres minor and the subscapularis internally, the teres major externally and the scapular head of the triceps above. Having cleaned the accessible portion of the artery, displace the lesser teres muscle outward and follow the vessel in its ramifications in the infraspinous fossa, incising the infraspinatus muscle to such extent as may be necessary. If the injection has been successful, this vessel will be found to anastomose rather freely with the posterior scapular branch of the transversalis colli over the lower part of the scapula.

This anastomosis brings into communication the first portion of the subclavian artery or its third portion, (see p. 46) and the third portion of the axillary artery. It therefore plays an important part in establishing the collateral circulation after the application of a ligature to either of those vessels at any place between the points indicated.

THE PECTORAL REGION AND THE AXILLA.

The **bony structures** concerned in the dissection of the anterior part of the chest-wall should claim the dissector's attention as a preliminary to the work of dissection. The **clavicle** presents the larger *sternal extremity* with a sternal articular facet, and a vertically flattened outer

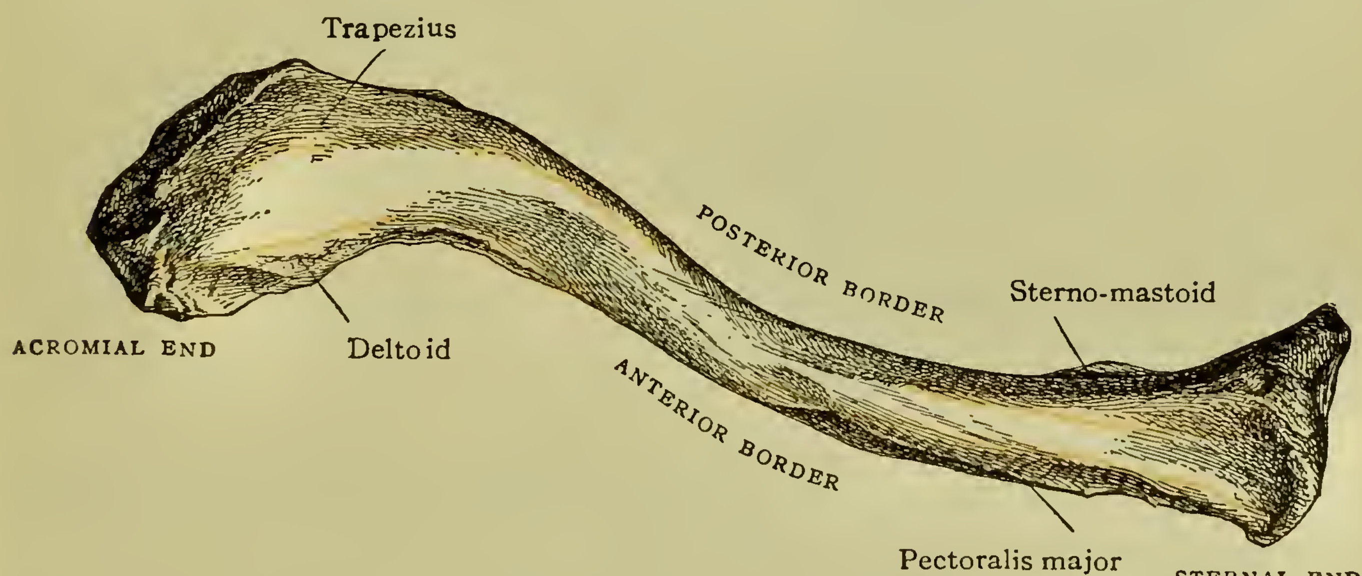

Fig. 16.—Right clavicle, superior and posterior surfaces.

or *acromial extremity* with a smaller acromial articular facet. The association of the clavicle with the scapula to form the shoulder-girdle should be noted on the articulated skeleton. The *upper surface* of the clavicle (Fig. 16) presents as the only noteworthy features, the four areas for muscular attachment, while the *inferior surface* (Fig. 17), beginning at the sternal extremity, exhibits the sterno-hyoid area, the rhomboid impression for the rhomboid ligament, the subclavian groove or fossa for the subclavius muscle, the conoid tubercle and the trapezoid ridge.

The **sternum** and **ribs** need receive no special attention at this time save to note their general relations in the skeleton, the relation of the first rib to the clavicle, and the oblique directions of the ribs.

THE SURFACE ANATOMY.

The **clavicle** is a conspicuous feature of the superficial anatomy of the pectoral region (Fig. 18). As it is practically a subcutaneous bone, it may be followed readily throughout its entire extent by both inspection and palpation. Passing the finger along the bone to its outer end, one may note its articulation with the acromion process. Following the

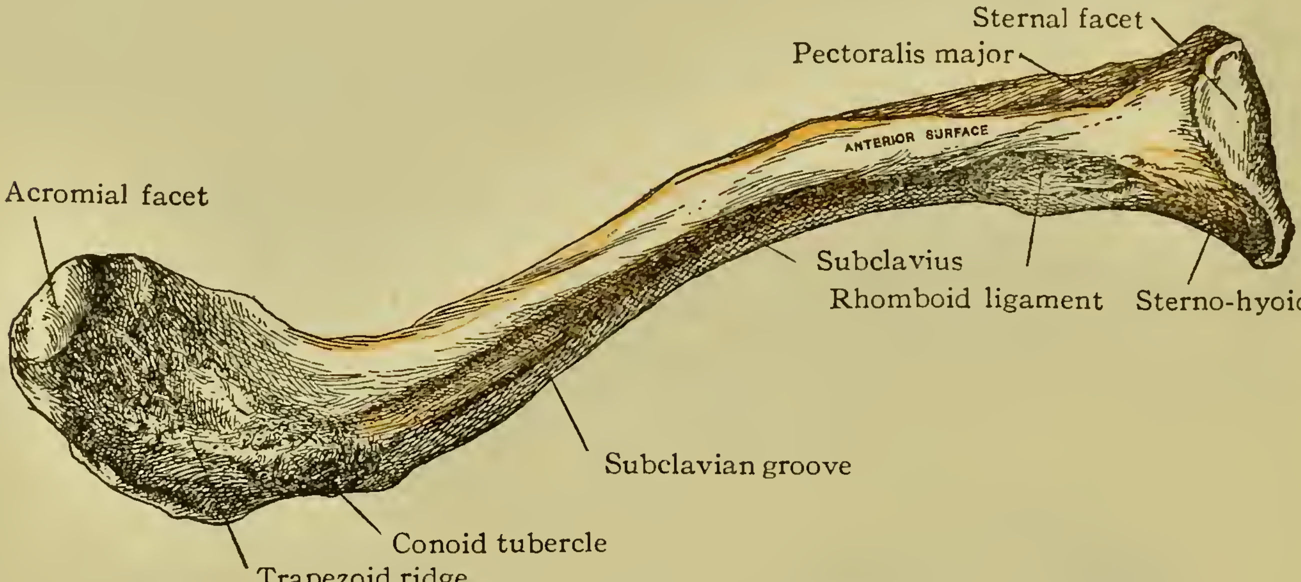

Fig. 17.—Right clavicle, anterior and inferior surfaces.

bone to its inner extremity, the finger abruptly sinks into the deep suprasternal (interclavicular) notch. At either side of this notch, below, may be felt the *sterno-clavicular joint.*

The range of motion of the sterno-clavicular joint is limited, yet it is an important feature of the function of the upper extremity, supplementing the movements of the shoulder-joint and the acromio-clavicular joint.

The **sternum,** covered only by the skin and fascia, except for the sternal origin of the greater pectoral muscle, is easily palpable. The articulation of the first costal cartilage with the manubrium, or first piece of the sternum, is somewhat masked by the sterno-clavicular joint. The second costal cartilage articulates with both the first and the second pieces of the sternum. The line of junction between the manubrium and the gladiolus is indicated by a ridge, the **sternal angle** or **angle of Lewis.** Passing the finger along the margin of the sternum, the articulations of the third, fourth, fifth, sixth and seventh costal cartilages will be discovered. At the lower extremity of the gladiolus, the finger encounters the **ensiform cartilage.**

The superficial position of the sternum renders it liable to slight injuries of a direct nature, but its relation to the ribs and their cartilages gives it relative immunity from fracture. When fracture does occur, its usual seat is at the junction of the manubrium and gladiolus. It is not infrequently the seat of syphilitic and tubercular lesions. The *angle of Lewis* may be exaggerated in disease, as in pulmonary emphysema and in pulmonary tuberculosis. *Congenital defects* due to arrest of development may exist in the form of apertures or of a median cleft, complete or partial.

The **ribs** may be readily palpated, except the first, which is obscured by the clavicle.

The **infraclavicular fossa** is a depression below the middle third of the clavicle. By fairly firm pressure here, in the living subject, the pulsations of the axillary artery may be felt.

The infraclavicular fossa may be effaced by the presence beneath it of the head of the humerus in subcoracoid luxation of that bone and by certain axillary growths; it may be replaced by a fulness or swelling in intracoracoid luxation of the humerus.

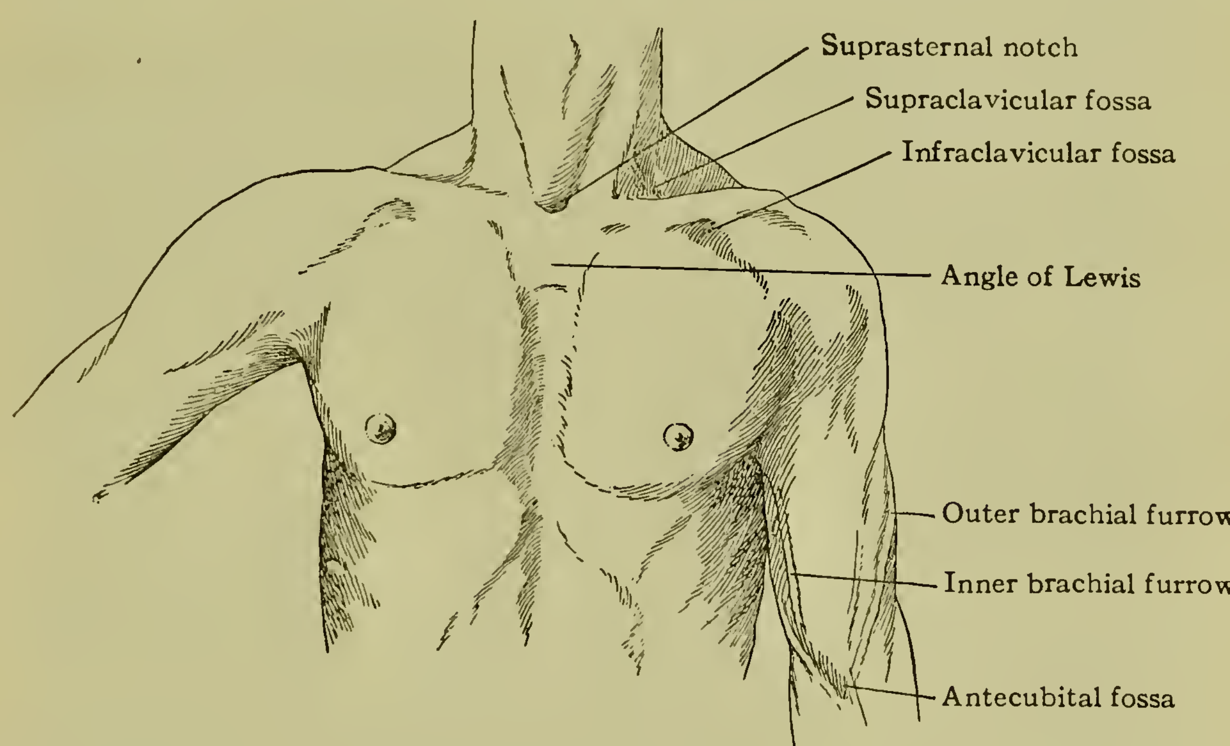

FIG. 18.— Surface anatomy of anterior chest-wall.

The **delto-pectoral furrow,** corresponding to the interval between the deltoid muscle and the greater pectoral, extends from the middle of the clavicle outward to the arm, an inch above the outer termination of the anterior fold of the axilla. It contains the cephalic vein and a branch of the acromial thoracic artery.

The **coracoid process** of the scapula is to be felt by rather firm pressure just below the clavicle and slightly external to the delto-pectoral furrow.

The **interpectoral furrow,** running from the sterno-clavicular articulation outward and somewhat downward to terminate a half inch above the union of the anterior axillary fold with the arm, indicates the interval between the sternal and clavicular portions of the pectoralis major.

The **mammary gland** in the male subject is usually so rudimentary as to be negligible; the nipple, however, in men, and in women with poorly developed glands, situated over the fourth intercostal space or over the fifth rib about five inches from the median line, serves as a land-mark in the physical examination of the thoracic viscera. Its position is variable in women with large and pendulous mammæ, depending upon the bulk and laxity of the gland. The female mamma extends laterally from the margin of the sternum to or sometimes beyond the border of the pectoralis major and in the vertical direction from the second to the sixth rib.

The skin of the nipple and of the areola surrounding it is delicate in texture, especially in the female, a circumstance which renders it liable to diseased conditions resulting from mechanical irritation. The areolar region is not infrequently the seat of superficial abscess in the female during lactation.

The **axilla** or **arm-pit** is seen as a narrow recess between the upper part of the arm and the chest-wall when the arm is placed close to the side of the trunk. With the arm abducted at a right angle to the trunk, the axillary interval is widened to a quadrilateral depression, which is bounded internally and externally respectively by the chest-wall and the arm, and anteriorly and posteriorly by the anterior and posterior axillary folds (Fig. 39). The depressed area enclosed by these boundaries is the **floor** of the axillary space. By palpation in the living subject the axillary artery may be felt and its pulsations noted near the outer extremity of this floor, at the junction of its anterior and middle thirds.

The *surface line* of the axillary artery is the line of junction of the anterior third of the floor of the space with the middle third, with the arm in abduction; another way of indicating the position of the artery is by a line drawn from the middle of the clavicle to the middle of the bend of the elbow, the arm being abducted.

Pressing the fingers deeply into the floor of the space about midway between the chest-wall and the arm, one encounters the resistance offered by the closely associated axillary artery and vein and the cords of the brachial plexus. The skin of the axillary floor is beset with hairs and is plentifully supplied with sebaceous and sweat glands.

The floor of the axilla is often the seat of superficial suppuration and of boils or furuncles. The lymph-nodes of the axilla are not palpable unless enlarged by disease. In downward, subglenoid, dislocation of the humerus the head of this bone is to be felt here.

DISSECTION OF THE CHEST-WALL.

Removal of the Skin.—Place a block under the shoulders and abduct the arm, supporting the latter upon a board. Make an incision from the sterno-clavicular joint along the line of the clavicle and directly over it, to the acromion process of the scapula (Fig. 19). From the middle of the clavicle carry an incision down the middle of the front of

the arm to a point on a level with the outer termination of the anterior fold of the axilla. From the lower end of this incision carry a short transverse cut across the arm to its inner side. Make a third incision along the mid-line of the sternum to its lower end and from this latter point carry a fourth incision outward and somewhat upward to terminate behind

FIG. 19.—Cadaver showing lines for incisions.

the line of the posterior axillary fold. Care should be exercised not to cut too deeply in making these incisions; it is desirable to cut only through the skin. The removal of the skin-flap thus outlined should be begun at the upper inner corner. The edge of the scalpel must be kept close to the deep surface of the skin—recognized by its white appearance in contrast with the yellowish tint of the subcutaneous

tissue—in order that the nerves and vessels may be avoided, and the superficial fascia left intact. This need not be difficult if sufficient traction is made upon the flap and if the parts are slightly moistened during the progress of the work. The dissection may be carried first along the sternum and then along the clavicle, and should be continued to such a degree as to expose the floor and the posterior fold of the axilla. This latter stage of the work may be deferred, however, until the mammary gland and the nerves and vessels of the chest-wall have been studied, in order to prevent undue drying of the tissues.

THE SUPERFICIAL FASCIA.—The superficial fascia contains the ramifications of the cutaneous nerves and vessels, hence it is not practicable to take it up as a continuous layer without sacrificing these to a considerable extent. If so taken up it will be found to be directly continuous with the same stratum of the adjacent regions. It contains more or less fat in its meshes according to circumstances. In the mammary region it consists of two layers between which the mammary gland is enclosed; elsewhere it is a single layer (Fig. 21).

The **superficial nerves** and **vessels** of the pectoral region should be sought and dissected before the removal of the superficial fascia. The **suprasternal** and **supraclavicular** branches (Fig. 20) of the cervical plexus (from the third and fourth cervical nerves) pass across the clavicle to the pectoral region and are most easily found as they cross this bone. Sometimes their detection is difficult, but it may usually be effected by a few superficial incisions directly over the clavicle and in an oblique direction, the edges of these incisions being retracted or teased apart, when the nerves will appear as more or less faintly marked bluish-white bands lying upon the surface of the deep fascia. The several nerves may then be traced to their terminations by carefully dissecting the fatty superficial fascia away from them, after which each one may be raised upon forceps to bring into view the numerous small branches. In the course of this dissection the fibres of origin of the platysma myoides will be encountered upon the deep fascia (Fig. 175); the nerves in question perforate this muscle variably, sometimes above the clavicle, sometimes below.

As some of the supraclavicular branches extend as far down as the skin of the mammary region, we have an explanation of the reference of pain to the cervical region in mammary carcinoma.

The **anterior cutaneous branches** of the intercostal nerves will be found perforating the deep fascia in the intercostal spaces close to the edge of the sternum (Fig. 20). The first one is usually quite small or may be absent. The nerves pass outward to a variable extent to be distributed to the integument, including a portion of the mammary region. In the detection of these nerves at their points of emergence through the great pectoral muscle and the deep fascia, the **anterior perforating**

branches of the internal mammary artery serve as guides, since they appear at approximately the same points as the nerves; not infrequently, however, they fail to receive their share of the color mass at the time of injection of the cadaver. These vessels are distributed to the superficial structures of the mesial portion of the pectoral region, the *third* and *fourth* helping to supply the mammary gland.

The **lateral cutaneous branches** of the intercostal nerves and the **lateral cutaneous branches** of the intercostal arteries should now be sought along the lateral region of the chest-wall, approximately along a line beginning, above, at a point a little behind the anterior axillary fold and inclining forward somewhat at the lower limit of the thorax.

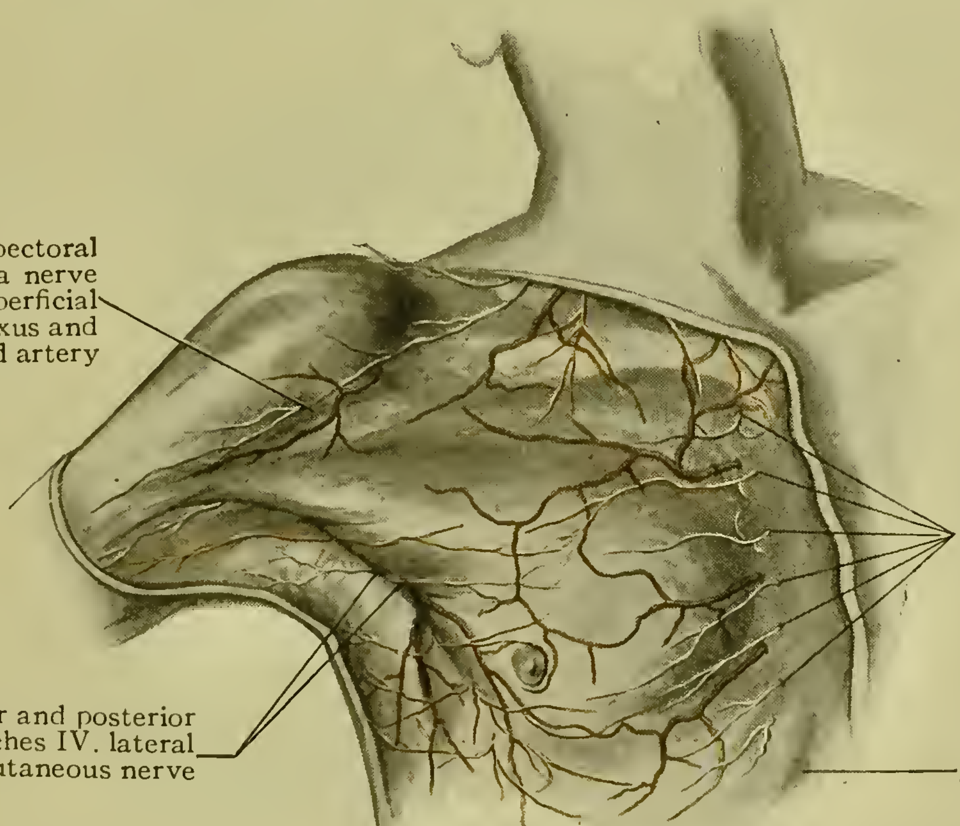

FIG. 20.—Superficial fascia, nerves and arteries of anterior chest-wall; anterior perforating branches of the internal mammary artery in close proximity to anterior cutaneous branches of intercostal nerves; superficial branch of long thoracic artery between lateral cutaneous branch of IV. intercostal nerve.

The nerves perforate the muscles and the deep fascia close to the lower border of the upper rib of the corresponding space and divide into their *anterior* and *posterior* branches (Figs. 20 and 11), which pass ventrally and dorsally respectively to be distributed to the skin. The first intercostal nerve gives off no lateral cutaneous branch; the *posterior* division of the lateral cutaneous branch of the *second* is of large size and passes across the axillary space as the intercosto-humeral nerve to the integument of the inner side of the arm, and will be encountered in the dissection of the axilla; the lateral cutaneous branch of the *third* intercostal sometimes joins either the intercosto-humeral or the lesser internal cutaneous nerve. The lateral cutaneous branches of the intercostal

arteries are small insignificant vessels. An important branch of the long thoracic artery will usually be found emerging from the axillary floor close to the edge of the anterior axillary fold; crossing the outer border of the great pectoral in the neighborhood of the fifth interspace, it breaks up into branches for the mammary gland.

So much of the superficial fascia as remains after the dissection of the nerves and vessels may now be removed as a layer, when the relation of the mammary gland to this fascia as indicated above becomes obvious. In removing the superficial fascia it is desirable not to encroach upon the deep fascia. As its dissection is continued over the anterior axillary fold it will be noted that this superficial stratum is not bound down but is directly continuous with the superficial fascia of the axillary floor.

Fig. 21.—The injected mammary gland. The portions showing red were injected through an aperture of the nipple.

The **mammary gland**—see page 30 for its location—is made up of sector-shaped lobes, the galactophorous, or lactiferous, ducts converging from the apices of the sectors to the region beneath the nipple and areola. For this reason, an incision for the evacuation of pus of a mammary abscess should be a radial incision so as to be parallel with the course of the ducts instead of cutting across them. The lobes of the gland are separated from each other by connective tissue septa, collectively designated the **suspensory ligament of Cooper,** which connect the superficial layer of the gland's envelope with the deep layer. Infiltration and consequent contraction of these septa produce the retraction of the nipple and of portions of the skin, characteristic of mammary

carcinoma. On the other hand, undue relaxation of the septa is present in overgrown and markedly pendulous glands. Intramammary abscess or inflammation may, for a time at least, roughly exhibit the form of the lobe in which it originates (Fig. 21).

The female mamma may be demonstrated by carefully dissecting from the anterior surface of the gland the superficial layer of the superficial fascia, a vertical incision having been made in the nipple line (Figs. 21 and 30). The lobes of the gland are so intimately related with the connective tissue septa that they are extremely difficult to separate; enough may be done, however, to give the dissector an idea of the structural features of the organ. A fine hypodermatic needle from which the point has been filed, introduced through one of the minute apertures of the nipple, serves as the avenue for the injection of a thin colored mass, such as red paint thinned with oil of turpentine, by which one or more lobes of the gland may be demonstrated (Fig. 21).

The **blood supply** of the gland is largely from the long thoracic branch of the axillary artery but also from the intercostals and from the perforating branches of the internal mammary; the venous blood is returned through the corresponding veins and therefore drains chiefly into the axillary vein.

The **lymphatics,** following the veins, pass for the most part into the axillary lymph-nodes, but some, following the tributaries of the internal mammary vein, pass to the anterior mediastinum. Hence, the axillary nodes are found enlarged in carcinomatous and septic conditions of the gland; but absence of such enlargement is not proof of absence of systemic infection in such diseased states of the gland, since those lymph-vessels that enter the mediastinal nodes may serve as avenues of systemic infection; further, there is not infrequently an interlacement of lymph-vessels of the two sides across the front of the sternum.

The Deep Fascia.—The deep fascia now exposed is seen to be an aponeurotic layer which closely invests the great pectoral muscle and which is attached along the clavicle and along the front of the sternum. Immediately below the clavicle will be seen the pale fibres of origin of the platysma myoides muscle. To detach the deep fascia as a continuous layer is a work of some difficulty, owing to its close relation to the great pectoral. It is desirable, however, to have at least a small flap at the axillary border of the muscle. Its removal will be made easier by abduction and outward rotation of the arm to make the muscle tense, and by making the knife-cuts in the direction of the muscular bundles and in a plane approximately parallel with them. As he approaches the delto-pectoral interval, the dissector must have regard for the cephalic vein and the thoracico-humeral artery. When the axillary border of the great pectoral is reached, the flap of deep fascia which has been raised will be seen to be continuous with a layer of fascia passing under the

muscle, as well as with that part of the deep fascia which passes across the floor of the axilla, the axillary fascia (Fig. 24). The latter need not be disturbed at this stage of the dissection.

It is evident that a collection of pus beneath the deep fascia would be arrested at the edge of the anterior axillary fold and might be guided to the delto-pectoral interval.

The Pectoralis Major (Fig. 22).—**Origin,** the inner half of the anterior border of the clavicle (pars clavicularis), the front of the sternum and the cartilages of the upper six ribs (pars sterno-costalis) and the

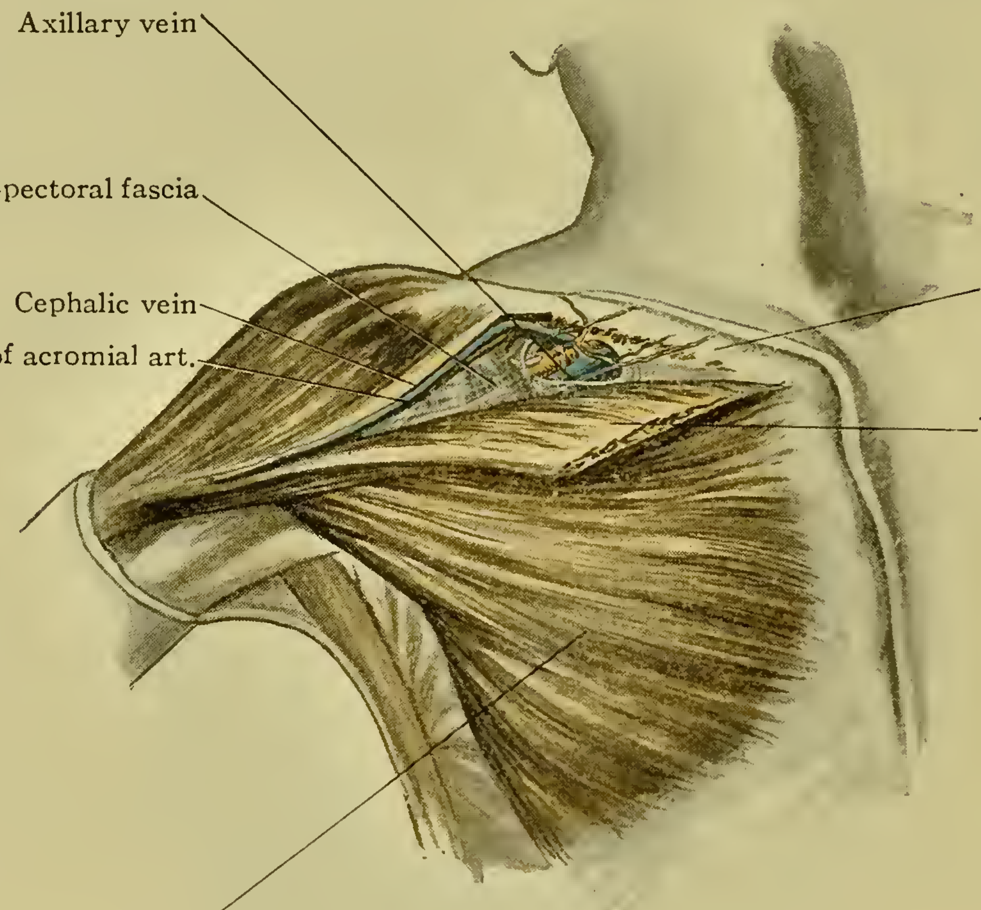

Fig. 22.—Pectoralis major, its clavicular portion reflected, exposing infraclavicular triangle.

upper part of the sheath of the rectus abdominis (pars abdominalis); **insertion,** the anterior (external) bicipital ridge of the humerus; **nerve-supply,** the lower four cervical and first thoracic, through the external and internal anterior thoracic nerves; **action,** adduction and internal rotation.

Following the muscle to its insertion, one notes that the lower portions of the tendon and the muscle are folded under the upper, the fibres of lowest origin having highest insertion; and also that from its tendon of insertion aponeurotic extensions pass upward over the long head of the biceps to blend with the shoulder-joint capsule and downward to the deep fascia of the arm, respectively. A small bursa is found between this tendon and that of the long head of the biceps.

The **sternalis muscle** (Fig. 23) is occasionally (about 4 per cent.) found in the pectoral region, arising from one or more costal cartilages as high as the third or as low as the seventh, or from the sheath of the rectus, and passing up to be inserted into the upper part of the sternum, the clavicle, or the tendon of the sterno-cleido-mastoid.

THE INFRACLAVICULAR TRIANGLE. — This triangle, the space of Mohrenheim, is exposed by detaching the clavicular portion of the great pectoral muscle—making an incision along the lower border of the inner half of the clavicle for this purpose—and reflecting it downward (Fig. 22).

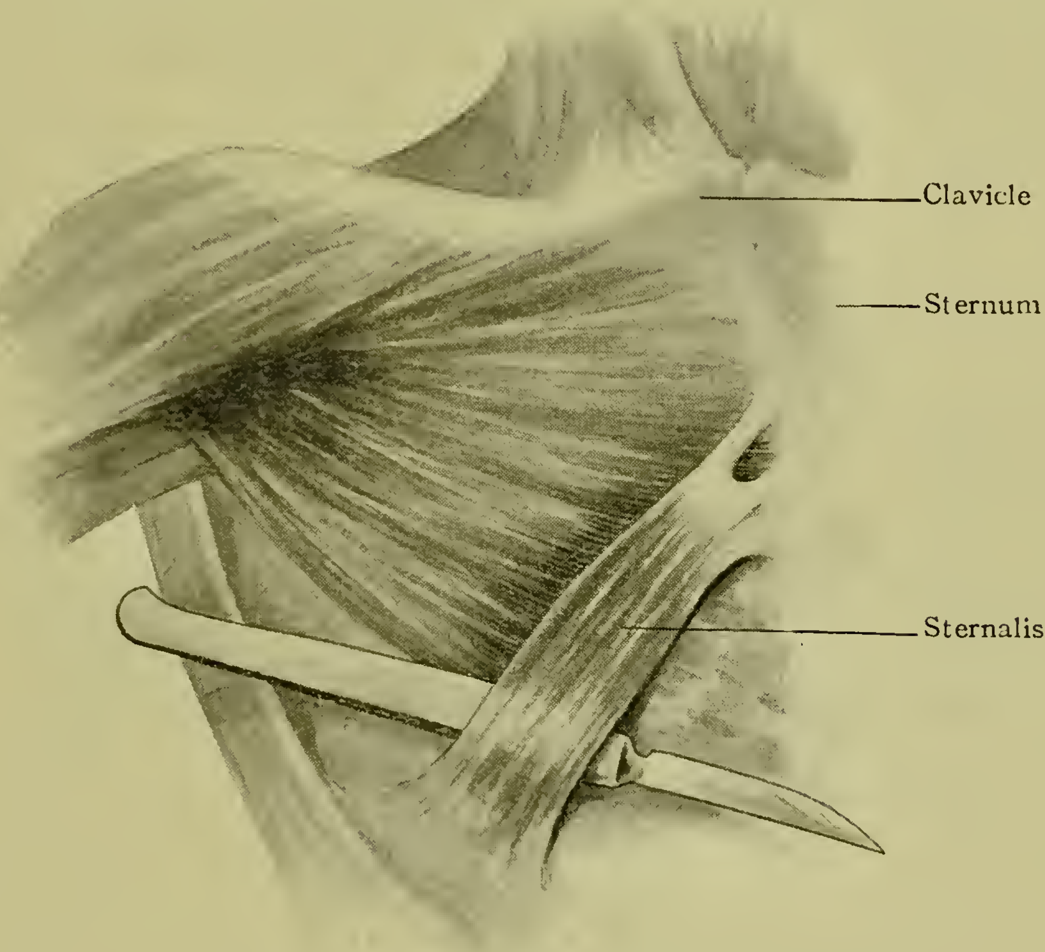

FIG. 23.—The sternalis muscle, arising from the aponeurosis of the external oblique and inserting into the gladiolus of the sternum. Drawn from a photograph of a dissecting-room preparation.

In raising this portion of the muscle, care must be exercised to avoid raising the underlying fascia with it. Gentle traction upon the muscular flap, a few light cuts with the knife and blunt dissection with the handle of the scalpel or with the blunt dissector, will accomplish the result. In making this dissection several small nerve-trunks will be encountered. They are the branches of the internal and external anterior thoracic nerves that go to the great pectoral muscle. Thoracic branches of the acromial thoracic artery will also be found passing to the deep surface of the muscle as well as its acromial branches (Fig. 27). Both nerves and arteries should be cleaned and should be preserved to as great an extent as possible. The **boundaries** of the triangular space now dis-

closed are the clavicle above, the deltoid externally and the border of the sternal portion of the great pectoral below. The **floor** of the space is the clavi-pectoral fascia. The **contents,** besides the arteries and nerves mentioned above, are the *cephalic vein*, passing inward from the outer boundary and disappearing through the fascial floor to join the axillary vein; frequently a vein, the *jugulo-cephalic*, which passes from the cephalic vein over the clavicle to join the external jugular vein; and the *acromial* and the *acromio-humeral* branches of the acromial thoracic artery, which come up through the floor of the space.

The dissector should now, with as little mutilation of the clavi-pectoral fascia as possible, follow the cephalic vein through this fascia, by blunt dissection, to its termination in the axillary vein. The latter may be partially exposed by cautiously separating the overlying fascia and enveloping connective tissue; continuing this process, the axillary artery will be found on the upper and outer aspect of the vein and the large trunks of the brachial plexus on the outer side of the artery. If the nerve branches referred to above are followed through the clavi-pectoral fascia, they may be traced, the outer to the outer cord of the brachial plexus and the inner to its inner cord, the latter nerve coming forward either between the axillary artery and vein or piercing the vein itself.

It is quite evident from the foregoing that the first portion of the axillary artery could be approached for operation through the infraclavicular triangle. The relation of this triangle to axillary growths and to anterior dislocations of the humerus is referred to on page 29.

The Clavi-Pectoral Fascia.—This fascia, a sheet of connective tissue beneath the great pectoral muscle, has been seen in part in the dissection of the infraclavicular triangle. To expose it more fully, the great pectoral muscle should be incised close to its sternal origin, from the top of the sternum to about the fourth or fifth costal cartilage. If this muscular flap be cautiously raised, the clavi-pectoral fascia may be traced to the lower border of the great pectoral muscle where it will be seen to be continuous with the deep fascia of the chest-wall as well as with the axillary fascia, which latter closes in the floor of the axillary space (Fig. 24). At a short distance from the lower border of the great pectoral muscle, the pectoralis minor is seen through the fascia. At its upper border the clavi-pectoral fascia is attached from within outward to the cartilage of the first rib, the under surface of the clavicle and the coracoid process of the scapula. The portion of it which is attached to the clavicle splits into two layers to enclose the subclavius muscle and to be attached to the anterior and posterior borders, respectively, of the subclavian fossa of the clavicle (Fig. 17). That part of this fascia which is above and internal to the lesser pectoral muscle is known as the *costo-coracoid membrane*, and the upper border of it, stretching from the first rib cartilage to the coracoid process of the scapula and attached

to the clavicle in the manner noted above, is the so-called *costo-coracoid ligament.* This may be demonstrated as a tense band by passing the tip of the finger along the fascia immediately below the clavicle, the tension relaxing when the shoulder is raised somewhat from the block. The superficial layer of the costo-coracoid ligament may now be reflected by lightly incising it directly below the clavicle and dissecting it downward for about a half inch, when the subclavius muscle will be exposed, and may be raised from its sheath by inserting a director under it (Fig. 30 and Fig. 35).

Following the clavi-pectoral fascia downward, it is found to split into two layers at the inner border of the lesser pectoral muscle, which,

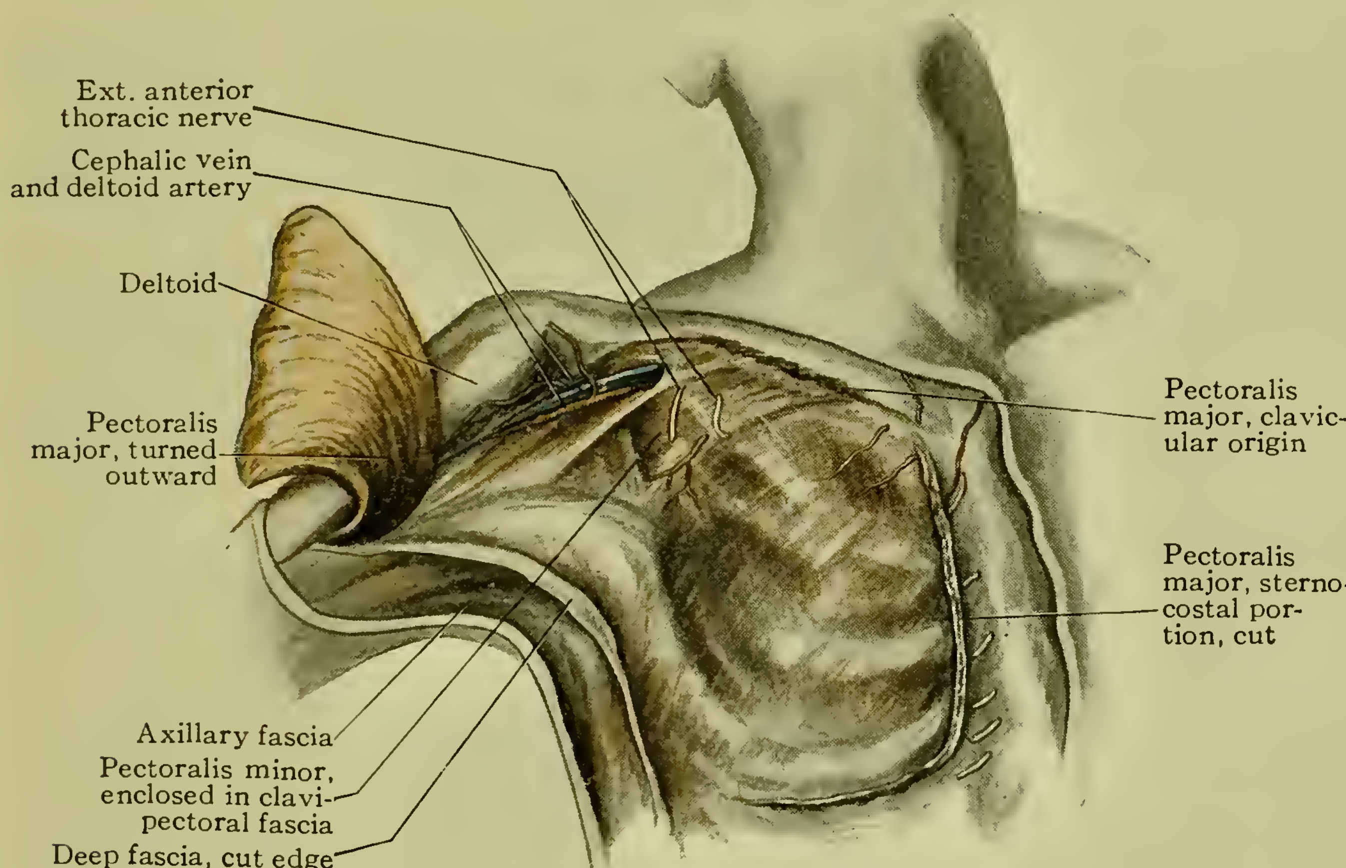

FIG. 24.—The clavi-pectoral fascia and pectoralis minor.

after enclosing the muscle, re-unite at its outer border to form a single layer. This should be demonstrated by incising the superficial layer over the middle of the muscle and dissecting the two small flaps of fascia toward the inner and outer borders of the muscle. The muscle should then be cautiously raised—but not cut—beginning at the inner edge and gently freeing it from the underlying fascia, in order to demonstrate the deep layer of the clavi-pectoral fascia (Fig. 25). In raising the muscle, the dissector will encounter the filaments of the internal anterior thoracic nerve passing either into its deep surface, or around one or other border to the superficial surface.

If now an attempt be made to raise the clavi-pectoral fascia as a layer it will be found that it is prolonged into the axillary space in the

form of connective tissue processes, which, passing from its deep surface, become continuous with the sheath of the axillary vessels. For this reason, this fascia is also known as the *suspensory ligament of the axilla.* Attached to its deep surface a short distance below the clavicle is a prolongation of the layer of the deep fascia of the neck, which passes into the axilla beneath the clavicle.

A collection of pus superficial to the clavi-pectoral fascia and beneath the great pectoral muscle would be limited by the attachments of this fascia. Thus, it would be arrested above by the clavicle, it would be shut off from the floor of the axilla by the union of the clavi-pectoral, the deep pectoral and the axillary fasciæ; and it would be shut off from the axillary space. It would therefore tend to make its way to the delto-pectoral interval.

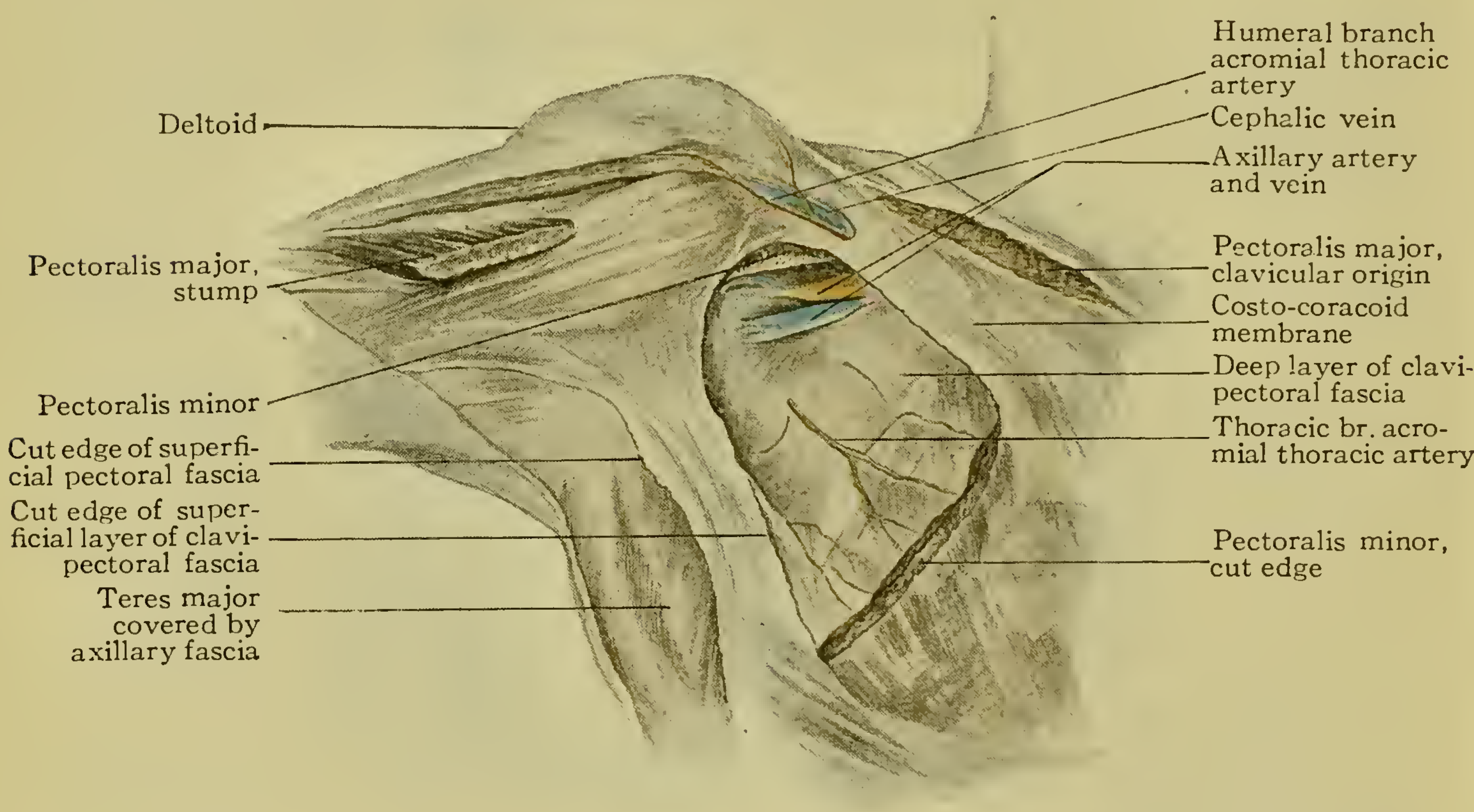

Fig. 25.—Dissection of thoracic wall; pectoralis minor has been partly removed, exposing deep layer of clavi-pectoral fascia.

The Subclavius Muscle (Fig. 35).—**Origin,** the first costal cartilage; **insertion,** the subclavian fossa on the middle third of the under surface of the clavicle; **nerve-supply,** the fifth and sixth cervical nerves through a special branch; **action,** to depress and draw forward the outer end of the clavicle.

The Pectoralis Minor (Fig. 25).—**Origin,** the third, fourth and fifth ribs and the external intercostal fascia; **insertion,** the coracoid process of the scapula; **nerve-supply,** the seventh and eighth cervical and first dorsal through the external and the internal anterior thoracic nerves; **action,** to draw the lateral angle of the scapula and with it the shoulder downward and inward; if the scapula is fixed, to draw the ribs upward and outward and so aid respiration.

This muscle, as already seen, is enclosed by the clavi-pectoral fascia (Fig. 24). The axillary vessels and nerve-plexus lie beneath its upper part; it serves as a landmark, therefore, in dividing these vessels, for descriptive purposes, into three parts. The muscle should be left intact in order to study this relation at a later stage of the dissection.

THE DISSECTION OF THE AXILLA.

As a preliminary to the dissection of the axillary space the great pectoral muscle should be replaced in its original position and should be retained by stitches. The arm must then be placed in the position of abduction, supported on a board. As the skin and superficial fascia have already been removed, the **deep** or **axillary fascia** is exposed stretching across the floor of the space.

The **boundaries** of the **floor** are the anterior fold, formed by the outer border of the great pectoral muscle; the posterior fold, constituted by the latissimus dorsi and the teres major; while the inner and outer limits are the chest-wall and the arm respectively.

The **boundaries** of the **axillary space** or the **axilla** are, in front, the greater and lesser pectoral muscles, the deep pectoral fascia and the clavi-pectoral fascia; behind, the upper or terminal portion of the latissimus dorsi, the teres major and the subscapularis muscles, with the subscapular fascia; internally, the chest-wall from the first to the fourth or fifth ribs with the corresponding serrations of the serratus magnus (serratus anterior) muscle; externally, the upper part of the arm, *i.e.*, a part of the humerus and of the coraco-brachialis and biceps.

The shape of the space is four-sided pyramidal, the sides converging toward the apex, which is at the interval between the first rib, the upper border of the scapula and the clavicle. The floor of the space represents the base of the pyramid.

The **axillary fascia** is a dense membrane which usually contains some muscular fibres. This muscular tissue is commonly arranged in such manner as to form a curved band, the **axillary arch,** whose concavity looks toward the arm and bounds an aperture in the axillary fascia, the foramen of Langer (Fig. 41), through which lymph-nodes may protrude. The muscle of the axillary arch is attached by its upper or anterior extremity to the tendon of the great pectoral or to the coraco-brachialis or to the fascia covering the biceps, while its opposite end is continuous with the tendon of the latissimus. Occasionally a more pronounced muscular development is encountered here in the form of a muscular slip passing from the border of the latissimus across the axillary vessels to the coracoid process of the scapula, or to the tendon of the coraco-brachialis, and joined by a slip from the great pectoral (Fig. 26).

The *axillary arch*, when well developed, may cause slight embarrassment in the operation for the ligation of the third part of the axillary artery, while the adventitious

muscular slip noted above may prove an even greater source of embarrassment. The denseness of the axillary fascia constitutes a barrier to the progress of an accumulation of pus in the axilla to the surface; the latter will therefore tend to follow the axillary vessels into the neck.

The axillary fascia must now be removed by incising it along the anterior axillary fold and the chest-wall and dissecting it back beyond the posterior fold to a sufficient extent to expose the tendons of the latissimus dorsi and teres major. In incising the fascia along the chest-wall the nerves and vessels—particularly the long thoracic artery—should be avoided (Fig. 27). The insertions of the latissimus and the teres major should be noted (p. 18), as well as the bursa between them

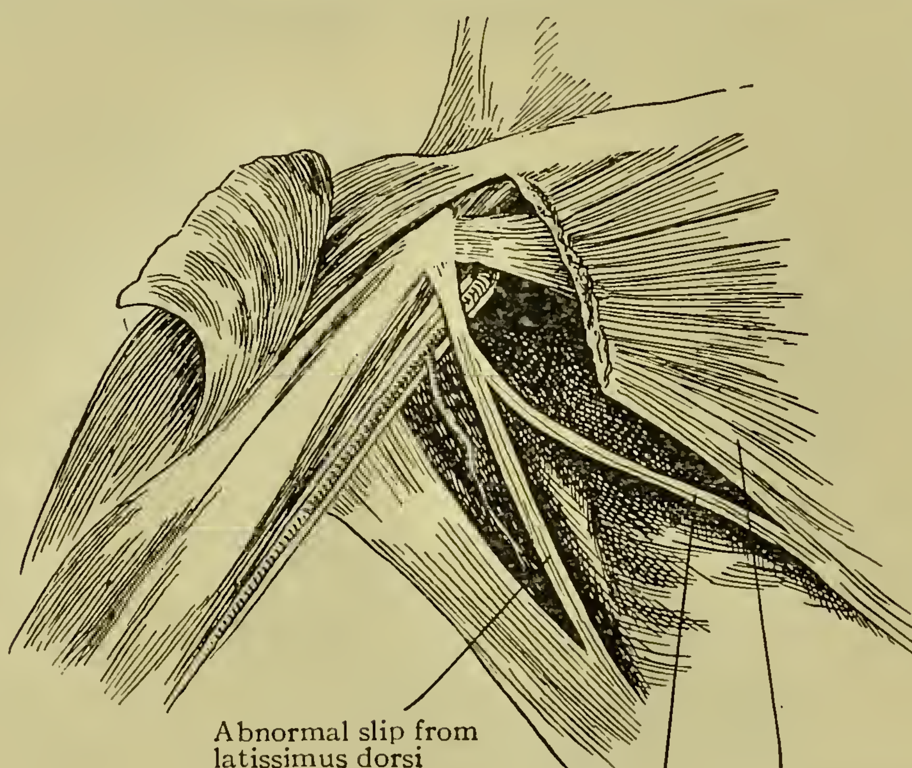

Fig. 26.—Anomalous muscular fasciculi from greater pectoral and latissimus dorsi.

(Fig. 32), and the fibrous slip which passes from the lower border of the tendon of the latissimus to the deep fascia of the arm. The fibrous slip referred to is sometimes muscular, the **dorso-epitrochlearis muscle,** passing either to the deep fascia or to the inner epicondyle of the humerus. The dissection of the contents of the axillary space practically consists in the removal, without injury to these structures, of the copious packing of fat and connective tissue in which they are embedded. To effect this, it is necessary to proceed cautiously, picking out the fat and connective tissue with forceps, aided by blunt dissection and the careful use of the scalpel, and being alert for the detection of nerves and vessels. It is possible to make the entire dissection without removing either of the pectoral muscles; this method is desirable since the relations of parts

are thus better preserved. In pursuing this plan, the work may be much facilitated by elevating the arm and moderately adducting it to relax the great pectoral and increase the antero-posterior diameter of the space. The dissector who considers this method beyond his skill may remove the great pectoral muscle, leaving the lesser pectoral *in situ*, by detaching the former from its origin and reflecting it outward, after having proceeded as far with the work as possible without disturbing the muscle. Since the important structures of the axilla are in relation with its several walls, the work of removal of the areolar tissue and

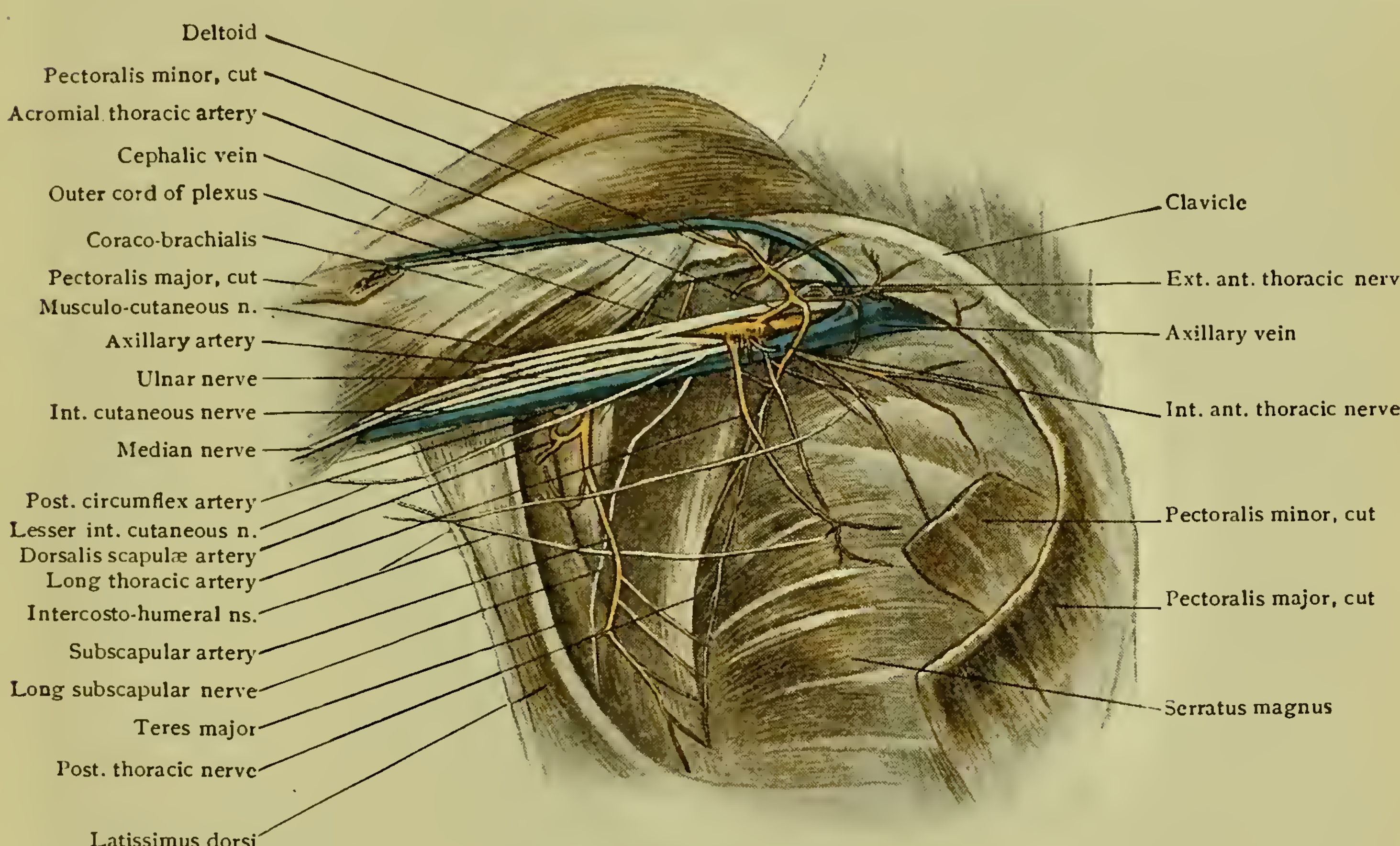

FIG. 27.—Dissection of axilla.

fat should begin in the middle of the floor. Very soon, the lymph-nodes of the intermediate and anterior thoracic groups will be encountered as small reddish nodular masses (Fig. 30). These nodes receive the lymph-vessels of the chest-wall. One of the first structures encountered in the central part of the space will be the **intercosto-humeral nerve,** the lateral cutaneous branch of the second intercostal (p. 16), passing across the space from the inner wall to the outer. As soon as discovered, the nerve should be followed to its origin on the chest-wall as well as in the opposite direction. Sometimes it is joined by a branch of the third intercostal nerve. It cannot be traced to its termination at this stage of the dissection, as it passes down the inner side of the arm, usually uniting with the lesser internal cutaneous nerve. It varies considerably in size, sometimes replacing the latter nerve.

The intercosto-humeral nerve is thought to be responsible for the pain in the left arm which is characteristic of angina pectoris, the intercostal nerve or nerves of which it is a branch being connected with the corresponding thoracic sympathetic ganglia which latter are probably connected with the deep cardiac plexus by way of the gangliated cord of the sympathetic, the inferior cervical ganglion and the inferior cervical cardiac branch arising from the latter. The pain of a diseased mammary gland may also be reflected along the course of this nerve.

In working through the central portion of the axillary space a small artery, the **alar thoracic,** a branch of the second part of the axillary, will be met with, distributed to the areolar tissue and lymph-nodes. It is sometimes absent, being replaced by branches from the other arteries of the axilla.

The Anterior Wall of the Axilla.—In relation at first with the anterior wall (constituted by the pectoral muscles and fasciæ) and further down with the inner wall, the **long thoracic** or **deep external mammary artery** (a. thoracico-lateralis) will be found as a vessel of considerable size (Fig. 28), giving *branches* to the great pectoral muscle and to the chest-wall, including the mammary gland, of which latter structure it constitutes the chief blood-supply. It is a branch of the second part of the axillary artery, usually, but may arise in common with the subscapular branch of that vessel. It *anastomoses* with the thoracic branches of the acromial thoracic, the subscapular, the intercostals and the anterior perforating branches of the internal mammary. The artery should be traced upward to its origin and its branches should be identified and cleaned.

In relation with the anterior wall of the axilla are to be found also the branches of the external and internal anterior thoracic nerves and some muscular branches of the acromial thoracic artery; these structures have already been encountered in the dissection of the infraclavicular triangle.

The Inner Wall.—The **anterior** or **pectoral lymph-nodes** in relation with the anterior and the inner walls of the axilla having been cleared away, the only other important structure found here, the **posterior** (or long) **thoracic nerve,** the so-called external respiratory nerve of Bell, is to be dissected. This nerve, a branch of the brachial plexus, arising above the clavicle, is formed in the substance of the middle scalene muscle by fibres from the fifth and sixth and usually also from the seventh cervical nerves; it emerges from the outer surface of the muscle and passes through the apex of the axilla, behind the axillary vessels and the brachial plexus, in front of the first serration of the serratus magnus and along the inner wall of the axillary space (Fig. 27), to be distributed to the serratus magnus muscle. Both the nerve and the muscle are covered by a rather dense fascia which may mask the nerve, although it may usually be discovered without difficulty.

The *posterior thoracic nerve* should be carefully avoided in operations upon the axilla because of the importance of the serratus magnus, the muscle it supplies, to the movements of the arm, any injury to the nerve which causes paralysis of the muscle resulting in the condition known as "winged scapula" (p. 67).

THE POSTERIOR WALL.—In relation with the posterior wall of the axilla, formed by the subscapularis, the teres major and the latissimus

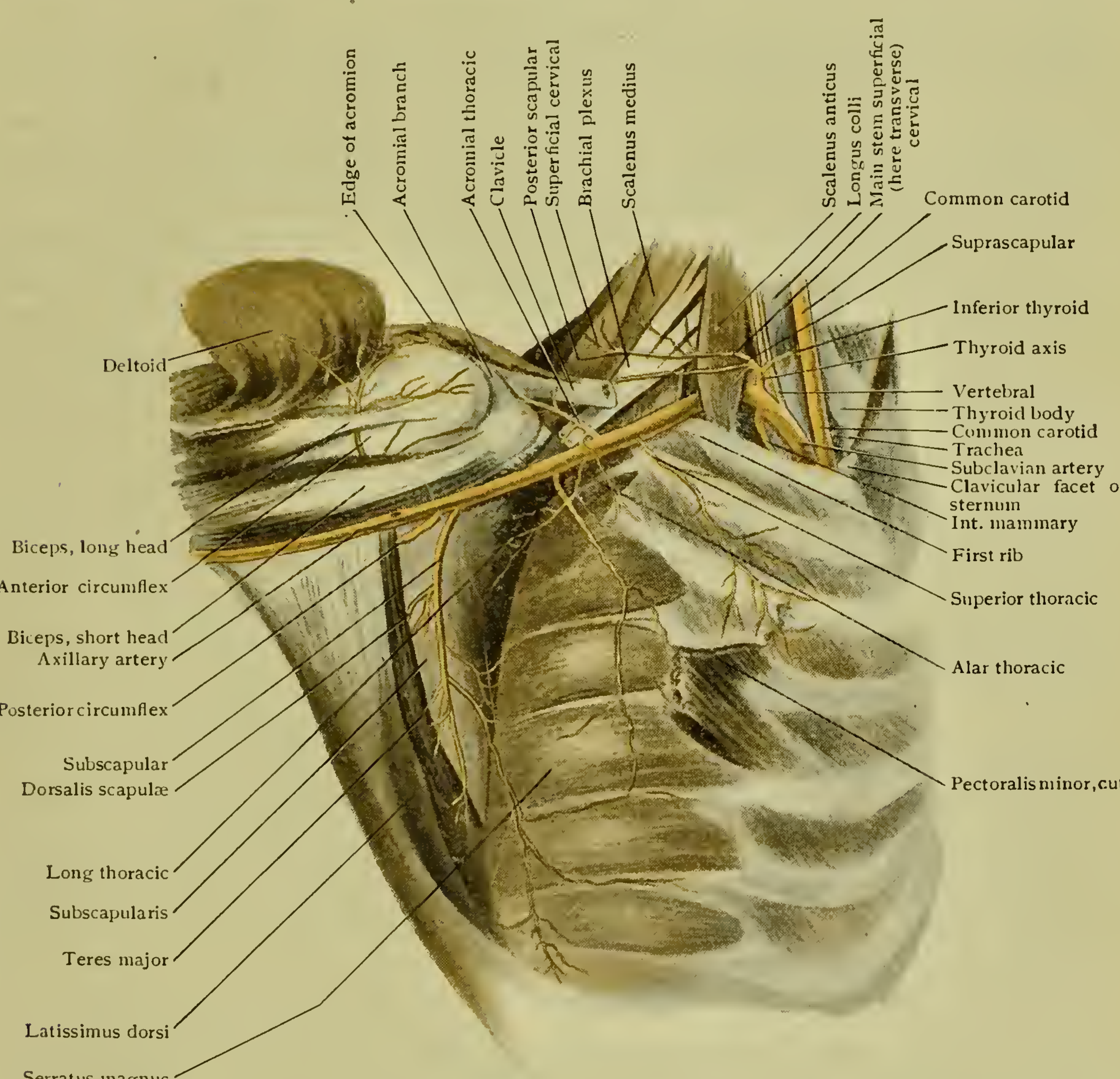

FIG. 28.—Deep dissection exposing subclavian and axillary arteries and their branches.

dorsi, are the **three subscapular nerves,** the **subscapular artery** and **vein,** the **posterior circumflex artery** and **vein,** the **circumflex nerve,** the **musculo=spiral nerve** and the **posterior group of lymph=nodes** (Fig. 30).

The **subscapular artery** (Fig. 28) should be identified and carefully cleaned, first toward its termination and then toward its origin, which is the third part of the axillary artery. In clearing away the connective tissue the dorsal or subscapular lymph-nodes, which receive the lymph-

vessels from the dorsal aspect of the thorax and shoulder, and the long subscapular nerve will be found in close proximity to the artery and should be conserved. In following the artery and nerve upward, a large branch of the artery, the dorsalis scapulæ, will be encountered curving around the outer border of the subscapularis muscle (Fig. 28) to pass dorsad through the triangular muscular interval (Fig. 14); a short distance farther up, the lower subscapular nerve enters the axillary border of the subscapularis; above this are the posterior circumflex artery and the circumflex nerve, close to the shaft of the humerus, passing over the outer border of the subscapularis to disappear through the quadrilateral interval (Figs. 28 and 14) on their way to the posterior aspect of the shoulder. The musculo-spiral nerve also rests against the posterior wall, close to the border of the subscapularis muscle. These structures are mentioned in this connection by way of cautioning the dissector against overlooking and injuring them.

The presence of the posterior circumflex and subscapular veins may cause some embarrassment to the dissector, as they are of rather large size; if so, they should be removed, after tying them close to their terminations in the axillary vein. The **subscapular artery** is the largest branch of the axillary and though usually arising from the third part of that vessel, near the axillary border of the subscapularis muscle, it sometimes arises from the second part, or from the brachial, or by a trunk common to it and to one or both circumflex arteries. It passes downward with the long subscapular nerve to the inferior angle of the scapula. Its largest *branch* is the dorsalis scapulæ, which passes through the triangular muscular interval (Fig. 14) to reach the dorsal surface of the scapula where it anastomoses with the posterior scapular and suprascapular arteries (Figs. 15 and 33); besides which, it distributes *branches* to the latissimus, the teres major and the chest-wall. The importance of its anastomoses with reference to the ligation of the axillary or of the subclavian is indicated on p. 27.

The **middle** or **long subscapular nerve** (n. thoraco-dorsalis), the largest of the three subscapular nerves, arises from the posterior cord of the brachial plexus, obtaining its fibres from the sixth, seventh and eighth cervical nerves. Passing downward and outward across the subscapularis (Fig. 27), it accompanies the subscapular artery and enters the axillary surface of the latissimus near the floor of the axilla, dividing into several branches as it does so.

The **lower subscapular nerve** (Fig. 29), arising from the posterior cord of the plexus below the point of origin of the middle subscapular, and obtaining its fibres from the fifth and sixth cervical nerves, also passes obliquely downward and outward across the posterior axillary wall. It enters the teres major after having given branches to the lower part of the subscapularis.

The **upper subscapular nerve** (Fig. 29), arising from the posterior cord of the plexus on the proximal side of the origin of the middle nerve, and deriving its fibres from the fifth and sixth cervical nerves, lies so deeply placed on the upper and inner part of the posterior wall as to be somewhat difficult to find. It enters the upper part of the subscapularis after a short course.

It will be seen that the three subscapular nerves collectively supply the three muscles that constitute the posterior wall of the axilla. Their situation, in close relation with this wall, protects them from injury.

The **circumflex nerve** (n. axillaris), one of the terminal branches of the posterior cord of the brachial plexus, and consisting of fibres derived from the fifth and sixth cervical nerves, will be encountered crossing the axillary border of the subscapularis muscle, in company with the posterior circumflex artery (Fig. 27). Traced upward, it is seen to arise from the plexus behind the axillary artery, a short distance from the border of the subscapularis; traced in the opposite direction, it may be followed through the quadrilateral muscular interval bounded by the humerus, the scapular head of the triceps, the teres major and the teres minor (Fig. 14). Its further course will be followed after dissecting and raising the deltoid muscle (p. 58). Its **branches** are two, sometimes three, *articular twigs* to the shoulder-joint, one of them arising near the origin of the nerve, while another is given off in the muscular interval mentioned above; *cutaneous branches* to the skin over the deltoid; and *muscular branches* to the teres minor and deltoid (Fig. 15).

Any injury to the circumflex nerve of a serious nature causes paralysis and consequent wasting of the deltoid with a corresponding loss of the characteristic rotundity of the shoulder and interference with the movements of the arm. The proximity of the nerve to the shoulder-joint renders it liable to stretching and to laceration in luxations of that joint, while its close relation with the surgical neck of the humerus lays it open to injury in fractures of this part, as well as subjects it to the risk of compression against the bone, as for example by a crutch-head, which may thus produce one form of "crutch-paralysis."

The **posterior circumflex artery** (Fig. 28), arising usually from the third portion of the axillary, sometimes in common with the subscapular or with the anterior circumflex, accompanies the circumflex nerve across the axillary border of the subscapularis and through the quadrilateral muscular interval (Fig. 14); as in the case of the nerve, its further course will be followed at a later stage of the dissection (Fig. 15). Its *branches* are distributed to the shoulder-joint and to the deltoid muscle chiefly.

The **musculo-spiral nerve** (n. radialis), one of the largest branches of the brachial plexus and the larger of the two terminal branches of its posterior cord, arising behind the third portion of the axillary artery and composed of fibres from the sixth, seventh and eighth and sometimes from the fifth cervical nerves, lies in contact with the upper outer part

of the posterior axillary wall (Fig. 41) in close relation with the circumflex nerve. Traced distally, it is seen to pass to the inner and posterior aspect of the arm across the tendons of the latissimus and the teres major. One or more *branches* may arise from it just as it leaves the axilla: the internal cutaneous branch to the inner and posterior aspect of the arm and a branch or branches to the inner and the long heads of the triceps; these may all arise by a common trunk.

The position of the musculo-spiral nerve in the axilla and its relation to the humerus render it peculiarly liable to crutch-pressure, so that it is said to be the nerve most frequently the seat of "crutch-paralysis." (See also p. 49.)

THE SUBSCAPULARIS MUSCLE (Fig. 36).—**Origin,** the ventral surface of the scapula except near the neck of the bone, and the subscapular fascia; **insertion,** tendinously, into the lesser humeral tuberosity and the shoulder-joint capsule; **nerve-supply,** the upper and lower subscapular nerves from the fifth and sixth cervical; **action,** inward rotation of the humerus and, when the arm is abducted, adduction.

In exposing the subscapularis, the **subscapular fascia** is encountered. This is a rather dense fascia attached to the upper and the mesial borders and the inferior angle of the scapula. Between the tendon of the muscle and the joint-capsule is the **subscapular bursa** (Fig. 32) which is usually in communication with the joint-cavity. Although this muscle is mentioned in this connection, it cannot be satisfactorily examined until a later stage of the dissection.

The subscapular bursa is important in its relation to the shoulder-joint, since, of the bursæ in proximity to this joint, it is the one that most commonly communicates with the joint-capsule.

THE OUTER WALL.—In relation with the outer wall of the space—constituted as indicated on p. 41—are found the most important structures of the axilla, namely, the **axillary artery** and **vein** and the **brachial plexus of nerves.** These structures are associated with each other by, and enclosed within, a considerable quantity of connective tissue, which is intimately adherent to the artery and vein but is more loosely associated with the nerve-trunks. The latter may be recognized as dense bands and should be cautiously separated from each other and from the vessels by blunt dissection, due regard being paid the branches of the artery and the tributaries of the vein. After this preliminary separation, in the accomplishment of which the **external group of lymph-nodes** will be encountered in close relation with the axillary vein, the individual structures should be dealt with in the order and manner indicated below, each one being first isolated in the lower part of the axilla and followed upward.

The Lesser Internal Cutaneous Nerve (n. cutaneus brachii medialis, nerve of Wrisberg).—This, the smallest nerve-trunk of the group, will be found on the inner side of the axillary vein (Fig. 27). Raising

the nerve with the forceps or blunt hook, the dissector should divest it of connective tissue and trace it upward to its *origin* from the inner cord of the brachial plexus. Either in the axilla or in the upper part of the arm it is joined usually by the intercosto-humeral nerve (p. 43). It derives its fibres from the first thoracic nerve and is *distributed* to the skin of the inner and posterior aspects of the arm. It is sometimes absent.

The Internal Cutaneous Nerve (n. cutaneus antebrachii medialis).—This nerve, larger than the preceding, should now be sought on the front of the axillary artery (Fig. 27) and should be traced up to its origin from the inner cord of the brachial plexus. Its fibres are derived from the eighth cervical and first thoracic nerves. Its *distribution* in the arm and forearm will be seen later (p. 102).

The Ulnar Nerve.—This nerve-trunk, of still larger size than the preceding, will be seen in the interval between the axillary artery and vein (Fig. 27). After its isolation in the manner already indicated, it should be followed to its *origin* from the inner cord of the brachial plexus, of which cord it is one of the terminal branches, the other branch being the inner head of the median nerve. The ulnar derives its fibres from the eighth cervical and first thoracic nerves. It gives off no branches in the axilla.

The ulnar nerve is sometimes the subject of "crutch-paralysis" from being compressed against the humerus by a crutch-head.

The Median Nerve.—The *inner head* (Fig. 29) of the median nerve, one of the terminal branches of the inner cord of the brachial plexus, may be traced from the point of bifurcation of this cord, obliquely outward across the axillary artery to unite with the *outer head*, which latter should then be traced back to its source as one of the terminal branches of the outer cord of the plexus, on the outer side of the axillary artery. The inner head derives its fibres from the eighth cervical and first thoracic nerves; the outer head from the sixth and seventh cervical nerves. The median gives rise to no branches in the axilla. It should be cleaned distally as far as the extent of the dissection permits.

The Musculo-Cutaneous Nerve.—This trunk should be sought along the outer side of the axillary artery (Fig. 42) and may be picked up at its point of *origin* as one of the terminal branches of the outer cord of the plexus, which point will have been found in tracing up the outer head of the median. It derives its fibres from the fifth, sixth and sometimes the seventh cervical nerves. The nerve followed distally will be seen to enter the inner surface of the coraco-brachialis muscle, which it perforates. It may sometimes be rather difficult of discovery, being concealed by cellular tissue between the axillary artery and the coraco-brachialis.

The Brachial or Axillary Plexus.—Having isolated and cleaned the large terminal branches of the brachial plexus, the dissector should now

clear the connective tissue from the several cords of the plexus as far as the apex of the axilla. (Or this may be deferred until the artery and vein have been dissected.) The inner cord, lying on the inner side of the second portion of the axillary artery, will be seen to pass over the artery, as one follows it from below, to gain the outer side of the first portion of that vessel. Its internal anterior thoracic branch has already been encountered (p. 37). Displacing the artery and vein somewhat upward

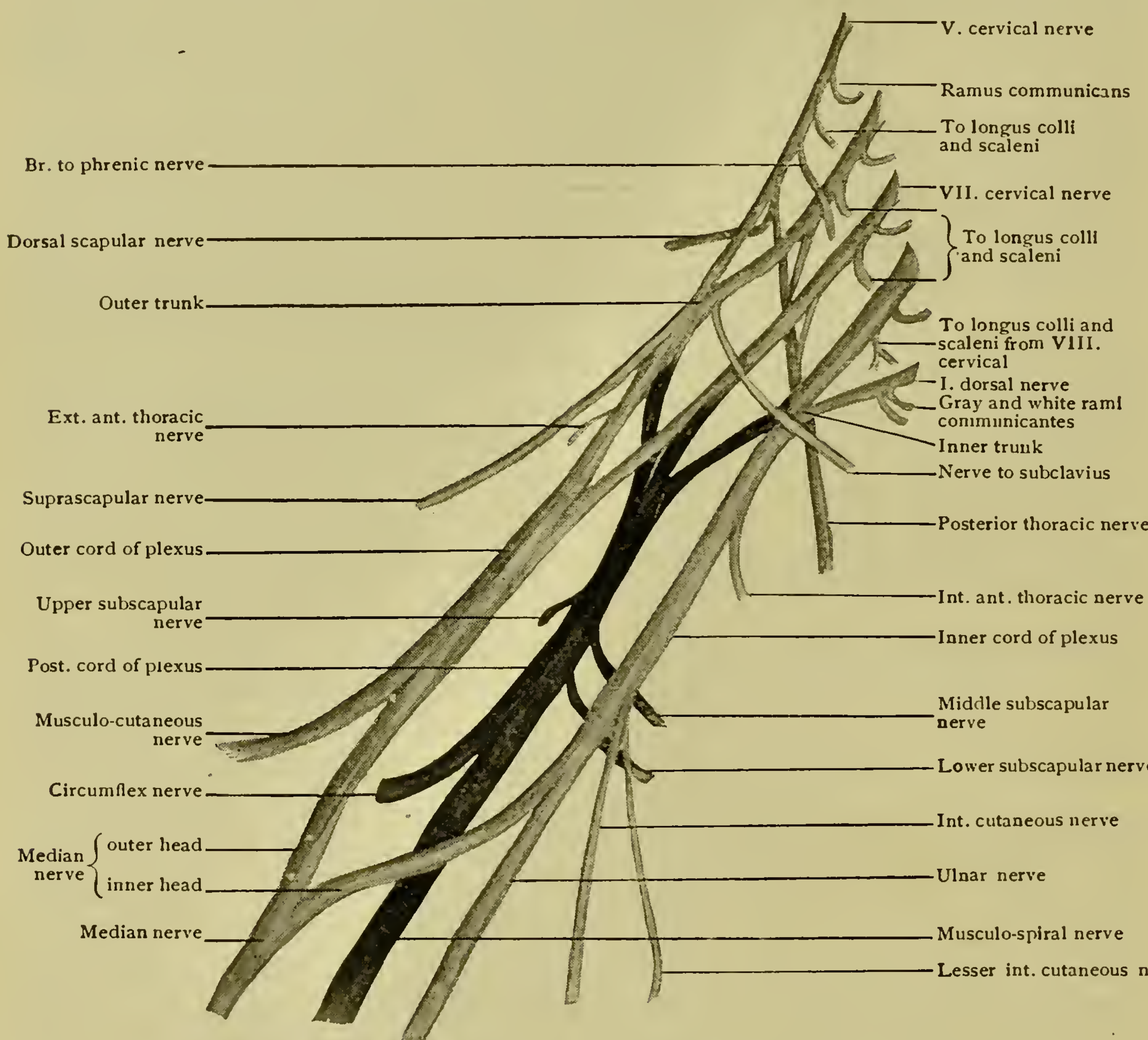

FIG. 29.—Diagram of brachial plexus.

and outward, the posterior cord will be found behind the second portion of the artery, and, like the inner cord, will be found to lie to the outer side of the first portion of the artery. Reference was made above (p. 46) to the three subscapular branches of the posterior cord. The outer cord of the plexus is external to the artery in both the second and first parts of the vessel's course. The external anterior thoracic branch was mentioned on p. 39.

The brachial plexus enters the axillary space through its apex, behind the clavicle and in front of the upper part of the serratus magnus,

being formed in the neck by the anterior divisions of the fifth, sixth, seventh and eighth cervical and of the first thoracic nerves (Fig. 29); (for details of formation, see p. 358).

The brachial plexus is sometimes torn in dislocations of the shoulder-joint and in attempts to reduce either recent or "old" dislocations, as well as in some other forms of violence to the upper extremity. It is sometimes the subject of inflammation and sometimes of neuralgia.

The Axillary Artery.—The *surface line* of this vessel is given on p. 30. By the dissection of the related nerve-trunks as indicated above, the artery is fairly well isolated. The axillary vein on its inner aspect, as well as any venous trunks found crossing it, should be carefully pushed aside, and any remaining connective tissue should be removed, care being exercised not to wound any of its branches. A slip of muscular tissue (p. 42) may be found crossing the lower part of the vessel. Instead of the single artery, one may find two parallel trunks, or the single vessel dividing into two in the lower part of the axilla (p. 78).

The **origin** of the axillary artery is at the outer border of the first rib as the continuation of the subclavian; it **terminates** as the brachial artery at the lower border of the latissimus and teres major tendons. Entering the axillary space through its apex, the *cervico-axillary passageway*, it passes obliquely along its outer wall. It is crossed by the pectoralis minor muscle, which serves to divide it into three portions (Fig. 27).

If the relation of the lower part of the axillary artery to the upper part of the humerus be noted, it will be seen that the vessel may be compressed in this part of its course, and here only, by pressure from within outward against the bone, the pressure being applied through the floor of the axilla over the course of the vessel. In this manner its circulation may be effectually controlled during operations.

From its relation to the shoulder-joint and its resulting subjection to disturbance on account of the wide range of motion of this joint, the axillary artery exhibits a special liability to aneurism. For the same reasons and also because of its relation to the humerus, it is peculiarly subject to traumatism, ranking next in this respect to the popliteal artery, being prone to injury in fractures and luxations, and especially in the reduction of "old" luxations.

The **first part of the axillary artery** is the part situate on the proximal side of the pectoralis minor. The **relations** of the first part are, on the *inner side*, the axillary vein, which slightly overlaps the artery; on the *outer side*, the brachial plexus; *behind*, the posterior or long thoracic and the internal anterior thoracic nerves, and the second and third digitations of the serratus magnus muscle overlying the first intercostal space; *in front*, the external anterior thoracic nerve, the terminations of the cephalic and acromial thoracic veins, the acromial and thoracic branches of the acromial thoracic artery, the costo-coracoid membrane and the great pectoral muscle.

It has been pointed out (p. 37) that this first portion of the axillary artery lies beneath the floor of the infraclavicular triangle (space of Mohrenheim) and is acces-

sible here for ligation by detaching and reflecting the clavicular origin of the great pectoral muscle. This is more difficult and hazardous however, on account of the vessel's depth and relations, than tying either the third portion of the subclavian or the third portion of the axillary. After ligation of this part of the vessel, if proximal to the acromial thoracic artery, the collateral circulation would be established by the anastomoses of the thoracic branches of the latter and of the long thoracic and subscapular with the intercostals and the internal mammary, as also by the communications between the dorsalis scapulæ of the subscapular and the posterior scapular and the suprascapular arteries.

The **branches of the first portion of the axillary** (Fig. 28) in their order of origin are the *superior thoracic* (a. thoracicalis suprema), a small vessel passing to the chest-wall which should be traced now if not already dissected; and the *acromial thoracic*, or *thoracic axis*, a much larger trunk, which arises from the front of the axillary close to the lesser pectoral. Sometimes these two arise in common. The **acromial thoracic** divides into *thoracic* branches for the chest-wall, including the serratus and the great pectoral muscles, anastomosing with the internal mammary; an *acromial* branch, anastomosing in the acromial region with the posterior circumflex and suprascapular arteries; a *descending* or *humeral* branch, which descends in the delto-pectoral interval with the cephalic vein; and a very small *clavicular* branch to the subclavius muscle.

The **second part of the axillary artery** lies beneath the lesser pectoral muscle. Its **relations** are, on the *inner side*, the axillary vein, the inner cord of the plexus and the internal anterior thoracic nerve, these two nerve-trunks intervening between the artery and the vein; on the *outer side*, the outer cord of the plexus; *behind*, the posterior cord of the plexus; *in front*, the pectoralis minor and major with their associated layers of fascia.

It will thus be seen that the second portion of the artery is even less accessible than the first portion, for which reason it is not selected for ligation.

The **branches of the second portion of the axillary** are the *long thoracic* (external mammary), which courses along the anterior axillary wall near the outer border of the pectoralis minor to reach finally the inner wall of the space, where it distributes branches to the mammary gland—of which it is the chief source of blood-supply—and to the serratus magnus and pectoral muscles, anastomosing with branches of the internal mammary and intercostal arteries; and the *alar thoracic*, distributed to the areolar tissue and lymph-nodes of the axilla, which is sometimes replaced by branches from some of the other axillary vessels. These vessels have been considered (p. 44).

The **third part of the axillary artery** is the part distal to the pectoralis minor. Its **relations** are, on the *inner side*, the axillary vein, the ulnar nerve and the point of origin of the inner head of the median nerve, between the artery and the vein, and the lesser internal cutaneous nerve on the inner side of the vein; on the *outer side*, the median nerve,

the musculo-cutaneous nerve, in the beginning of the nerve's course, and the coraco-brachialis muscle; *behind*, the musculo-spiral and the circumflex nerves, and the muscles of the posterior axillary wall; *in front*, the internal cutaneous nerve, the inner head of the median nerve, crossing obliquely from within outward, and the great pectoral muscle.

Since the third portion of the axillary artery is more easily accessible than the other parts, being situated near the floor of the space and being covered by only one muscle, the great pectoral, it is the part selected for ligation—the "point of election." Bearing in mind the surface-line of the vessel (p. 30), it is evident that it may be reached through the axillary floor. For this operation the arm is abducted, the hand and forearm supinated, and an incision is made through the junction of the anterior and middle thirds of the floor of the space, the axillary fascia being opened cautiously, and the areolar tissue and fat traversed in like manner until the axillary vein and median nerve are reached. The vein having been carefully displaced inward and the nerve outward, the artery is exposed and may be encircled by a ligature, the needle being passed from within outward to avoid injuring the vein. In exposing and tying the vessel it is essential to bear in mind the possibility of the presence of the *axillary arch*, the muscular slip which sometimes crosses it (p. 41), as well as the possibility of the presence here of two large arterial trunks instead of one (high division of the brachial, p. 78).

The **branches of the third part of the axillary** are the *subscapular* (considered on p. 45), and the *anterior* and the *posterior circumflex* arteries. The second branch of the third portion of the axillary is the *posterior circumflex*, arising from its posterior aspect and winding around the neck of the humerus, in company with its two veins and the circumflex nerve through the quadrilateral space bounded by the humerus above, the scapular head of the triceps below,—using these terms with reference to the abducted position of the arm,—the teres minor internally and the teres major externally, to supply the deltoid and the shoulder-joint, *anastomosing* with the tricipital branch of the superior profunda, the acromial thoracic and the anterior circumflex. The third branch, the *anterior circumflex*, much smaller than the posterior, arising from the outer side of the axillary, passes across the front of the surgical neck of the humerus, beneath the coraco-brachialis and the short head of the biceps to supply the deltoid and, by a branch which passes upward in the bicipital groove, the head of the humerus and the shoulder-joint. Continuing its course over the neck of the humerus, it anastomoses with the posterior circumflex artery (Fig. 33).

Noting the points of origin and the anastomoses of the branches of the third part of the axillary artery, it will be apparent that if this portion of the vessel be ligated on the proximal side of the subscapular branch, the collateral circulation will be established largely through the anastomoses between the dorsalis scapulæ and the posterior scapular and the suprascapular, thus linking the first and the third portions of the subclavian artery with the third part of the axillary; aided by the communications between the subscapular and the intercostals and internal mammary.

If ligation is performed distal to all the branches, the circulation is re-established through the anastomoses between the circumflex arteries and the superior profunda of the brachial.

The Axillary Vein.—The dissection of the axillary vein, if not yet completed, should be finished by clearing away any remaining cellular tissue, when it will be seen that the vein lies upon the inner side of the artery throughout its course, slightly overlapping it above. Its **origin,** at the lower and outer limit of the axilla, is from the confluence of the large basilic vein with the two venæ comites—or sometimes with but one—of the brachial artery; it **terminates** as the subclavian vein at the outer border of the first rib. As in the case of the artery, it is divided into three parts by the pectoralis minor muscle, these subdivisions being differently designated, however, since, the vein being an afferent vessel, the distal portion is the first and the proximal the third part.

The **relations** of the axillary vein, especially its relations with muscles, have practically been shown in treating of the axillary artery, its situation, near the clavicle, beneath the costo-coracoid membrane, having been pointed out on p. 38. On the *outer side*, between the vein and the artery, are found, first, from above downward, the internal anterior thoracic nerve, then the inner cord of the brachial plexus dividing into the inner head of the median and the ulnar nerves, and giving off the internal cutaneous nerve, which latter quits its close relationship with the vein to reach the front of the artery. On the *inner side* is the central chain of lymph-nodes and, in the distal half, the lesser internal cutaneous nerve. In addition to these relations, the vein is crossed, both in front and behind, by various branches of the axillary artery. The irregular beaded appearance of the injected vessel is due to the presence of valves, which usually are found, respectively, near the beginning, a little above this point opposite the subscapular vein, and near the end of the vessel.

The **tributaries** of the axillary vein are, first, the accompanying veins of the branches of the axillary artery. The **circumflex vein,** however, enters either the subscapular vein or a brachial vein instead of opening directly into the axillary. In addition to these, the **cephalic vein** enters the terminal portion of the axillary, after piercing the costo-coracoid membrane; the **costo-axillary veins,** from the upper five or six intercostal veins, connect those vessels with the axillary; and the **thoracico-epigastric vein** (Fig. 287), entering the long thoracic vein, brings blood from the lower part of the abdominal wall to the axillary vein.

The thoracico-epigastric vein is apt to enlarge in common with the other superficial veins of the abdominal wall, in cases of obstruction to the portal venous circulation, as in certain diseases of the liver.

The close association of the axillary vein with the costo-coracoid membrane, the latter tending to keep the vein patulous by traction upon its superficial wall, together with the fact that this vein shares with other large venous trunks in close proximity to the upper outlet of the thorax in the negative pressure or suction brought about in these vessels by the act of inspiration, renders this vessel peculiarly liable to the entrance of air if wounded. Such a bubble of air may prove fatal by embarrassing the action of the heart or by obstructing a branch of one of the pulmonary arteries.

Owing to its position on the inner side of the artery, its larger calibre and its weaker walls, it is subject to rupture in accidents to the upper extremity and to wound in axillary operations, since, in the latter, the axilla is invaded through its floor.

The Axillary Lymphatics.—The lymph-nodes of the axilla (Fig. 30), with their afferent and efferent vessels, though seemingly distributed indiscriminately throughout the areolar tissue and fat of the space, are arranged in rather definite groups. These nodes receive as their afferent vessels the lymphatics of the arm, of the dorsal surface

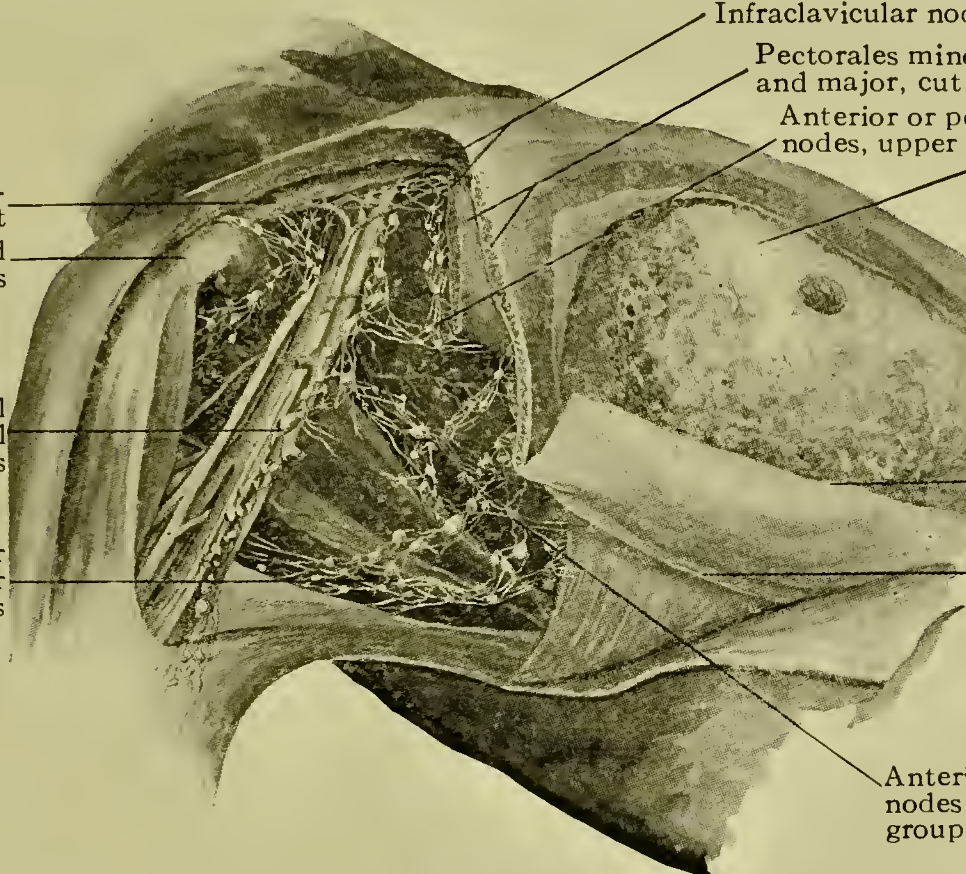

Fig. 30.—The lymphatics of the axilla. In addition to the groups of nodes indicated, the central group is also shown. Dissection made after multiple hypodermatic injection over and around the mammary gland of very thin black varnish, the lymph-vessels and nodes showing black in the dissection.

of the thorax and the scapular region, and of the lateral and ventral surfaces of the thorax including the mammary gland and the part of the anterior abdominal wall above the umbilicus. The lymph is passed on from them, through vessels that converge at the apex of the space to, usually, a single trunk, the *subclavian trunk*, which, from its origin opposite the first intercostal space, passes upward over the subclavian vein either to join the jugular lymph-trunk and thus to form, on the right side, the right lymphatic duct, or to empty independently into the termination of the right subclavian vein; on the left side of the body, the subclavian trunk terminates in the thoracic duct.

The **external,** or **brachial** or **humeral group** of lymph-nodes, situated along the inner side of the axillary vein chiefly, but partly beneath it, receives the lymph-vessels of the arm, except such as accompany the cephalic vein (Fig. 30).

The **anterior thoracic** or **pectoral group** consists of two or three (upper) nodes which rest upon the second and third intercostal spaces in relation with the long thoracic artery, and several other (lower) nodes, also in relation with the same artery, over the fourth and fifth spaces. They receive the vessels of the anterior and lateral portions of the chest-wall and the mamma, and of the supra-umbilical region of the abdominal wall (Fig. 30).

The **intermediate** or **central group,** embedded in the areolar tissue and approaching the floor of the axilla, receives vessels from all the other groups except the subclavicular (*vide infra*), to which it sends its efferent vessels.

The **subscapular** or **posterior nodes,** seated along the subscapular artery in relation with the posterior axillary wall, receive the lymph-vessels of the scapular region and of the dorsal thoracic wall.

The **subclavicular group** of nodes, at the apex of the axilla, receives the efferent vessels of all the other groups as its afferents, its own efferents converging as noted above, to form the *subclavian lymph-trunk.* Some of the efferent vessels of the external group of nodes pass by the subclavicular group to connect with the lower cervical nodes.

As any septic material, as from an abscess, a poisoned wound or a malignant growth, taken up by the lymphatic vessels is temporarily arrested by the nodes to which the vessels lead, the enlargement and tenderness of such nodes in consequence of the irritation is evidence of a septic process in the region drained by the vessels in question. Thus, in a mammary abscess or carcinoma, the axillary nodes first involved are those of the anterior pectoral group, followed by signs of irritation in the central and then in the subclavicular groups, and even in the lower cervical nodes. Owing to this disposition of the lymph-vessels it is important to extirpate all the axillary nodes and in some cases the lower cervical nodes when a cancer of the breast is removed. As indicated on page 30 the axillary lymph-nodes are not palpable when normal.

THE REGION OF THE SHOULDER.

THE SURFACE ANATOMY.

The rounded contour of the shoulder is due to the deltoid muscle supported by the head and greater tuberosity of the humerus.

The rotundity of the shoulder bears an important relation to abnormal conditions of this region and in case of suspected injury or disease of this part comparison should always be made with the shoulder of the opposite side. The normal contour may be lost on account of atrophy of the deltoid muscle, owing to disease of or injury to its nerve, the circumflex; to dislocation of the head of the humerus; to impacted fracture of the anatomical neck of the humerus in the elderly, resulting in slight flattening of the shoulder; to separation of the upper epiphysis of the humerus in the infant or adolescent, the upper end of the lower fragment forming a projection; and to tumors—sarcoma or enchondroma—of the humerus.

The **anterior border of the deltoid** and its relation to the great pectoral (Fig. 18) are easily recognized, and, especially when the muscle

is in action, its points of origin and insertion also. Above the middle of the muscle, may be felt the **acromion process of the scapula** and its articulation in front and within with the clavicle. Just external to the acromion, the **greater tuberosity of the humerus** may be felt when the arm is placed beside the trunk, but it recedes under the acromion when the arm is elevated; by firm pressure with the finger in front of the great tuberosity, the **lesser tuberosity** and the **bicipital groove** may be obscurely palpated as the arm is slightly rotated.

The outer extremity of the acromion process may be utilized as a point from which to measure the distance to the external condyle of the humerus to determine shortening in case of suspected fracture.

DISSECTION.

The Superficial Fascia.—Since the deltoid was exposed in part in the dissection of the back, there remains but a small portion to be denuded. Upon the removal of the skin and the exposure of the superficial fascia the **cutaneous nerves** should be sought. Descending over the acromion to the skin covering the deltoid will be found prolongations of the **acromial branches** of the cervical plexus (Fig. 40), and perforating the muscle, rather low, are **cutaneous filaments** from the muscular branches of the circumflex nerve, while the **cutaneous branch** of the same nerve will be found curving around the posterior border of the muscle, usually in several strands, to terminate in the skin over it (Fig. 46). These should be isolated and the superficial fascia should be removed.

The Deep Fascia.—The deep or deltoid fascia, a portion of the deep fascia of the arm, is only noteworthy as being rather more dense and aponeurotic than the other parts of the same structure. It may now be removed in order to expose the deltoid muscle, this being best accomplished by working in the direction of the muscular bundles.

The Deltoid Muscle (Fig. 31).—**Origin,** the outer third of the ventral border of the clavicle, the acromion process and the lower border of the spine of the scapula; **insertion,** the deltoid tubercle of the humerus; **nerve-supply,** through the circumflex nerve from the fifth and sixth cervical nerves; **action,** abduction of the arm to a right angle (further abduction necessitating the rotation of the scapula).

The general characters, including the coarse striation, and the origin of the fibres of the acromial portion from three or four parallel tendinous septa attached above to the acromion, and their insertion into two or three similar but alternating tendons at the lower end of the muscle, having been noted, the muscle may be reflected. This should be done by prolonging the transverse incision previously made into the posterior border, and carefully turning outward the distal portion, thus exposing the subjacent structures, including the subdeltoid bursa, and the ter-

minations of the circumflex nerve and the posterior circumflex artery (Fig. 15). Directions were given for the care of these structures on p. 23.

Reference has been made (p. 47) to the relation of wasting of the deltoid to injury or disease of its nerve.

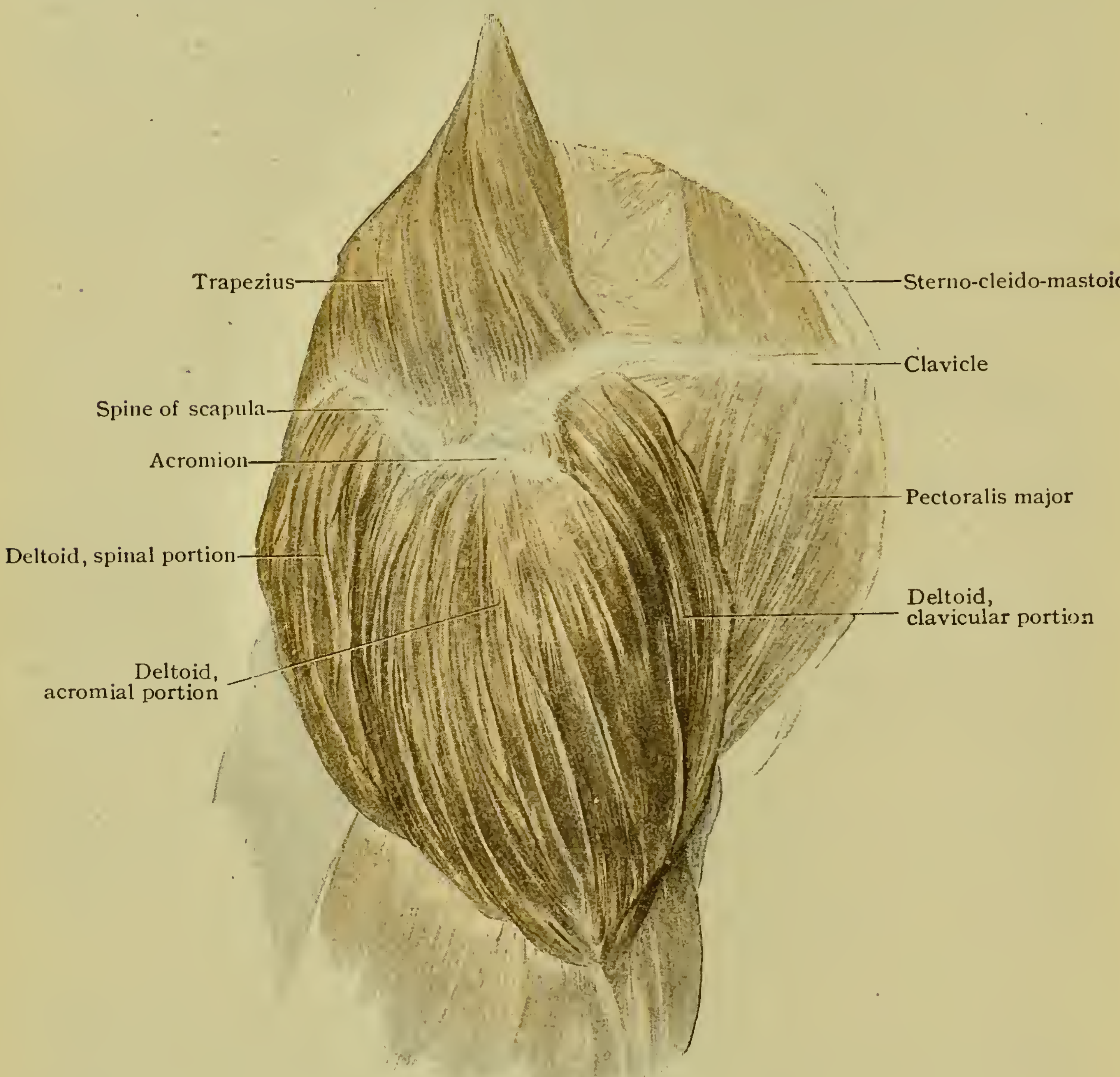

Fig. 31.—Deltoid muscle viewed from side.

The **subdeltoid bursa** (Fig. 32), between the deltoid and the greater tuberosity of the humerus, should be examined by noting first its size, while still intact, and then by incision and exploration of its cavity with the finger. It sometimes extends inward beneath the acromion process.

What was said of inflammation of the subacromial bursa on p. 23 in reference to its confusion with synovitis of the shoulder-joint is equally applicable to bursitis of the subdeltoid bursa: in the bursal inflammation, however, passive abduction of the arm, by relaxing the deltoid, is the position of greatest comfort.

The terminations of the circumflex nerve and of the posterior circumflex artery should now be traced (Fig. 15), any connective tissue which still adheres to them being removed. The course and termination of the artery were described on p. 47.

The branches of the circumflex nerve (p. 47) should be traced respectively to the deltoid, the skin over it, the teres minor and the shoulder-joint (Fig. 15).

The **bicipital groove** of the humerus, lodging the tendon of the long head of the biceps, should be examined, the tendon being raised and followed to its point of entrance into the joint-capsule. A synovial sheath is prolonged upon the tendon from the capsule of the joint to the extent of about a half inch (Fig. 32). A branch of the anterior circumflex artery will be seen to ascend in the groove to enter the joint.

The tendon of the long head of the biceps, arising from the scapula above the glenoid cavity, sustains an important relation to the shoulder-joint. Passing through the capsule, but not through the joint-cavity proper, since it is invested by the synovial membrane of the joint, it serves as an elastic ligament of this joint, contributing to the security of the articulation against upward dislocation. Thecitis of the tendon (inflammation of its sheath), being attended with much pain upon motion, may simulate synovitis of the joint.

The Acromio-Clavicular Joint (Fig. 32). — The **articular surfaces** involved in this **arthrodial** joint are the outer end of the clavicle and the inner border of the acromion process of the scapula. The **ligaments** are the *superior* and *inferior acromio-clavicular*, continuous with each other to form a capsule, and the *interarticular disk* (Fig. 33). The latter sometimes completely divides the joint-cavity; more commonly it divides it incompletely; and sometimes it is absent. The **blood-supply** is from the suprascapular artery. The **range of motion** is limited but very important, supplementing that of the shoulder-joint.

The superior ligament should be incised, when the interior of the joint may be examined. The inferior portion of the capsule should not be disturbed at present.

The **supplementary ligament**, the **coraco-clavicular** (Fig. 32), contributes very materially to the strength of this articulation. It consists of the *conoid ligament* (Fig. 32), a conical band, attached by its apex to the base of the coracoid process and by its base, directed upward, to the conoid tubercle on the under surface of the clavicle and to a line passing inward from this tubercle; and of the *trapezoid ligament* (Fig. 34), a quadrilateral band situated externally to the conoid, attached below to the upper border of the coracoid process and above to the oblique line of the clavicle. These should be examined as well as the present stage of the dissection will permit. After or during the course of the dissection of the shoulder-joint, the disarticulation of the acromion process from the clavicle may be completed; this will demonstrate the

importance of the trapezoid and conoid ligaments in maintaining the union between the scapula and the clavicle. The clavicle may then be sawn just external to these ligaments to exhibit them more fully.

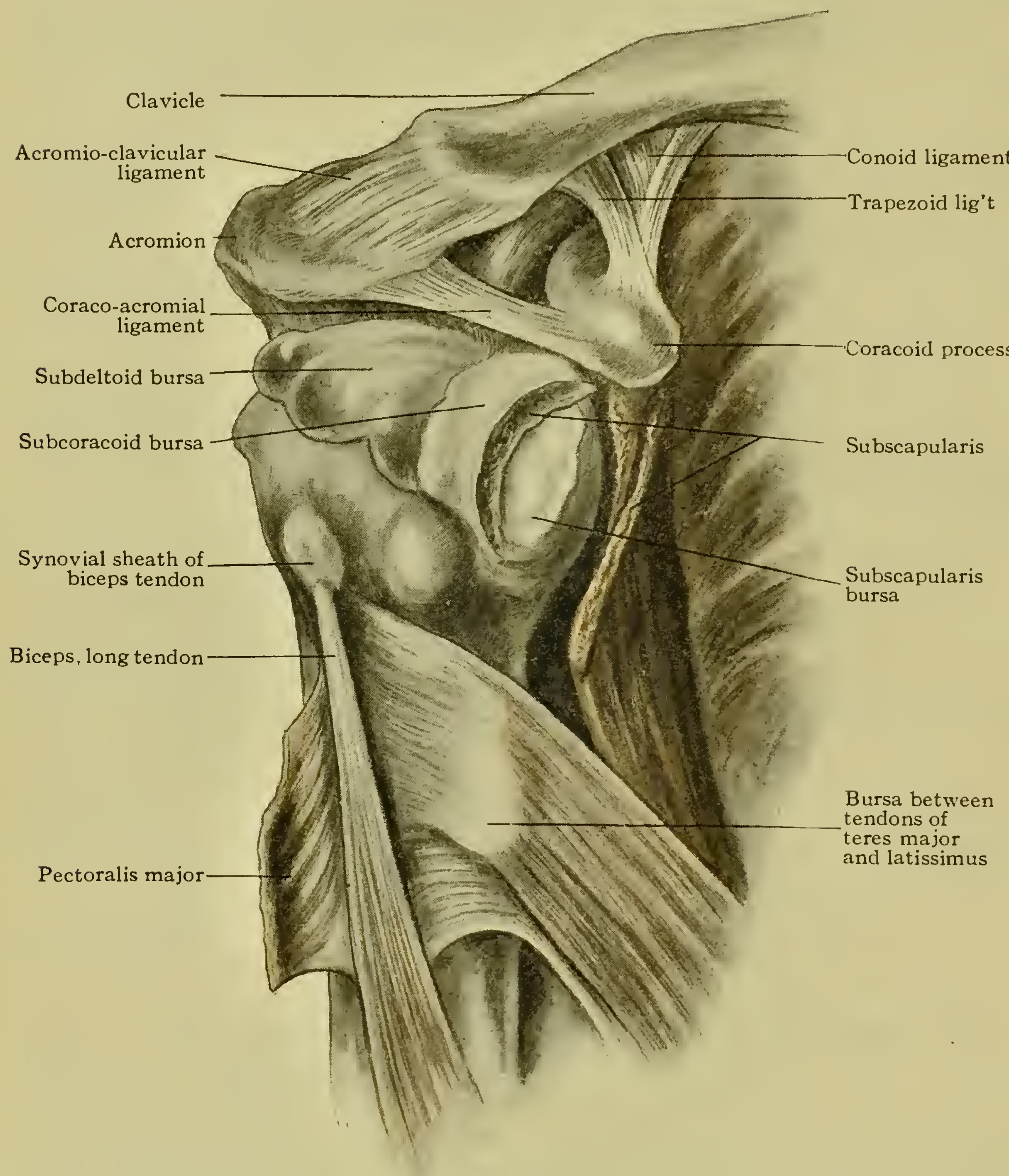

Fig. 32.—Acromio-clavicular joint and shoulder-joint from without and in front, showing distended bursæ.

The acromio-clavicular joint may usually be easily recognized in the living subject by palpation, the slight projection of the clavicle assisting. Owing to the shallowness and limited extent of the articular surfaces, the joint would be very insecure but for the presence of the coraco-clavicular ligament. The most usual displacement is a downward dislocation of the acromion, the outer end of the clavicle projecting upward.

The acromion may also be dislocated upward. The difficulty of maintaining the bones in apposition is a characteristic feature of these luxations.

THE SHOULDER-JOINT (Fig. 32).—The **articular surfaces** involved in this articulation are the shallow glenoid cavity of the scapula and the head of the humerus, constituting an **enarthrosis.** The **ligaments** are the rim-like *glenoid* (Fig. 34), serving to deepen the glenoid cavity; the *capsular* (Fig. 33), connecting the margin of this cavity with the anatomical neck of the humerus; the *transverse*, bridging the upper end of the bicipital groove and so binding down the long tendon of the biceps;

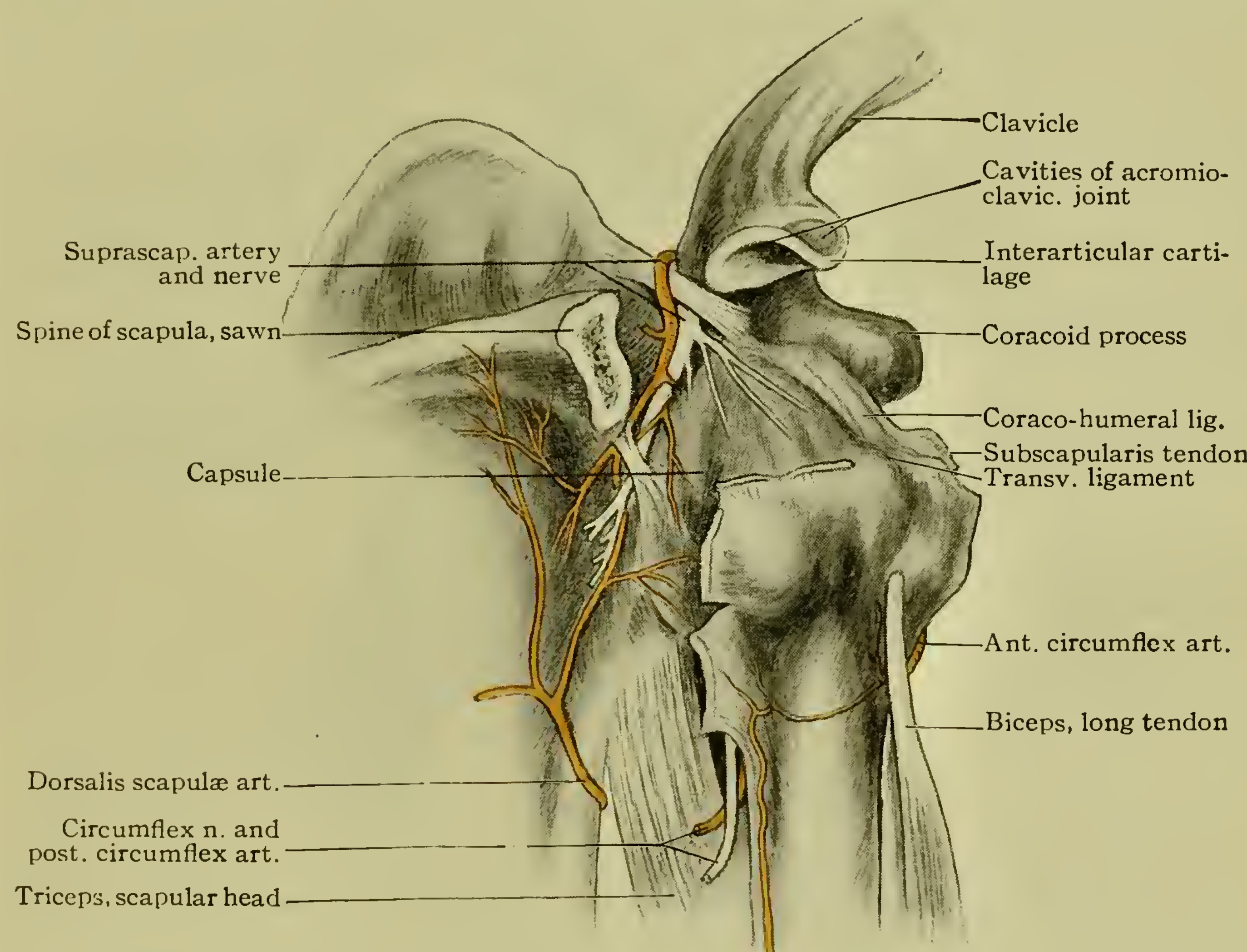

FIG. 33.—The right shoulder-joint, postero-lateral aspect. The spine of the scapula has been sawn through and the acromion disarticulated from the clavicle.

and the *coraco-humeral* (Fig. 33), connecting the base of the coracoid process with the greater tuberosity of the humerus and intimately connected with the capsule. **Supplemental bands,** appearing as localized thickenings of the upper, the lower and the front part of the capsule, exist as the gleno-humeral ligaments. Of these, the *superior gleno-humeral* (Fig. 34), seen only on the deep surface of the capsule, is attached to the upper inner portion of the border of the glenoid cavity and to the lesser humeral tuberosity; the *middle gleno-humeral* or *ligament of Flood*, seen upon the inner surface of the capsule, is an ill-defined

band connecting the inner edge of the glenoid cavity with the lower part of the lesser tuberosity; while the *inferior gleno-humeral* or *ligament of Schlemm*, apparent on both inner and outer surfaces of the capsule, passes from the lower border of the glenoid cavity to the inner part of the neck of the humerus. The **blood=supply** is contributed by the supra-scapular and the circumflex arteries (Fig. 33). The **nerve=supply** is from the suprascapular and circumflex nerves (Fig. 15).

The **relations** of the shoulder-joint to surrounding structures should be studied after having exposed the joint but before incising its capsule. Above the joint will be seen the acromion process of the scapula and

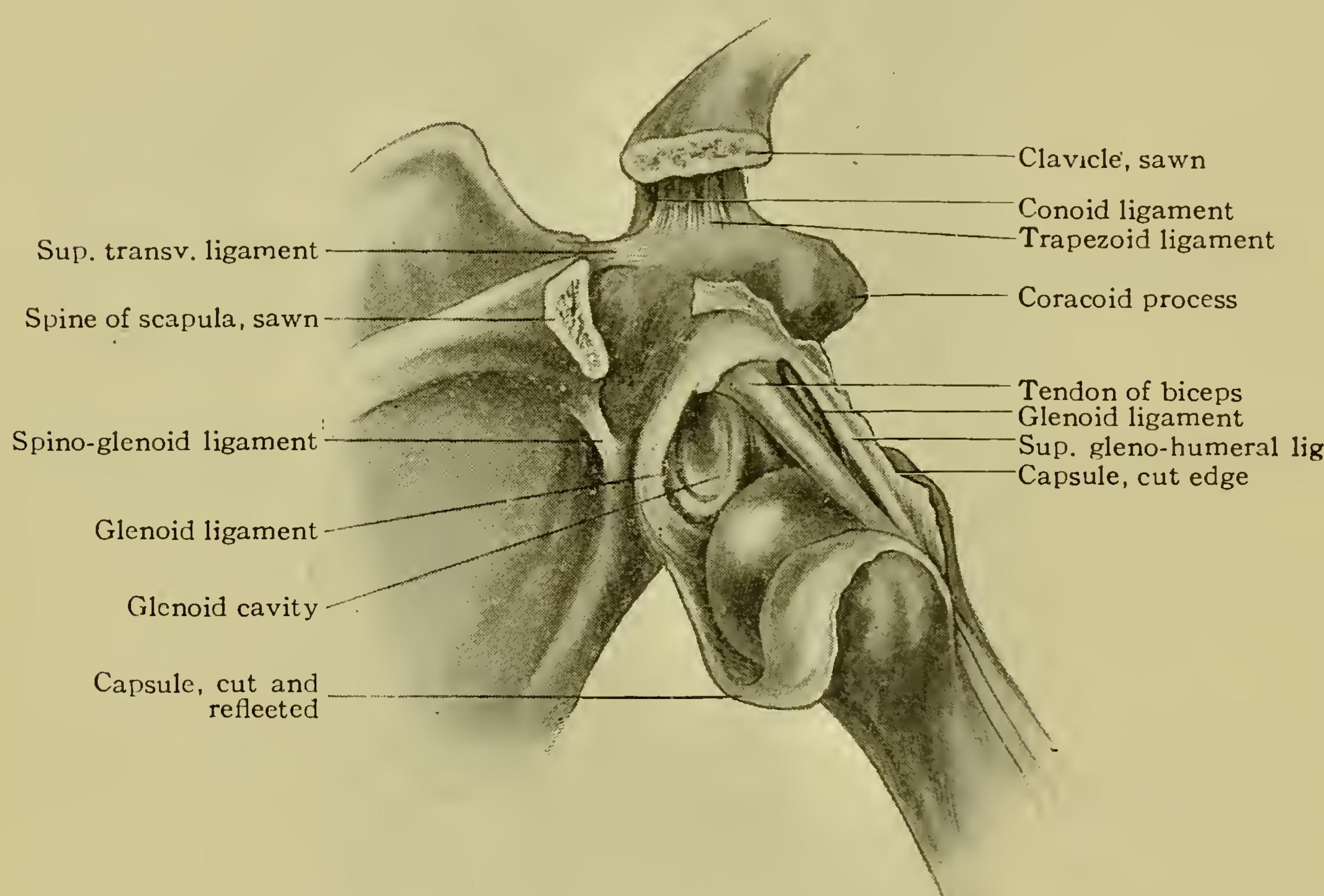

Fig. 34.—The right shoulder-joint, postero-lateral view, the capsule opened and reflected.

the **coraco=acromial ligament** (Fig. 32) passing from the acromion to the coracoid process. The relation of the deltoid and of the subdeltoid bursa to this aspect of the joint has been indicated (Fig. 32). More intimately related to the capsule is the supraspinatus tendon.

On the anterior aspect of the joint, is the subscapularis tendon, separated from the capsule by the **subscapular bursa** (Fig. 32), the largest and most constant of the related bursæ and the one most usually in communication with the joint-cavity.

On the inferior aspect, though not in close relation except in extreme abduction, is the scapular head of the triceps.

On the posterior aspect, above, is the tendon of the infraspinatus, not infrequently separated from the capsule by the **infraspinatus bursa,**

which usually communicates with the joint-cavity; while below this, is the teres minor tendon.

The relations of nerves and vessels have been sufficiently indicated in the preceding sections.

After the removal of restraining muscles and tendons from about the joint it will be seen that the head of the humerus still remains in its place in the glenoid cavity, though the capsular ligament is seen to be lax and therefore to be exercising no supporting influence upon the bone. If a puncture be made in the capsule, admitting air to its cavity, the head of the humerus drops from the socket or may be easily displaced, showing that atmospheric pressure is the chief agent in maintaining the apposition of the bones.

The redundancy of the capsular ligament is directly related to the wide range of motion peculiar to this joint, this redundancy being necessary to permit of the extended movements of the upper extremity. It is scarcely necessary to point out that parts of the capsule become tense in certain positions of the arm; hence the importance of the localized thickenings above noted.

The capsule of the joint should now be dissected, the first step being the isolation of the coraco-humeral ligament (*vide supra*). Beneath the proximal part of this ligament will be found the **subcoracoid bursa** (Fig. 32). An incision through the capsule along the outer border of the long tendon of the biceps and eversion of the inner lip of the incision will reveal the course of the tendon through the joint-cavity and its relation to the synovial membrane which ensheathes it, the sheath (vagina mucosa intertubercularis) being prolonged as far as the surgical neck of the humerus (Fig. 32). Along the inner border of the tendon, on the deep surface of the capsule, will be seen the fold of synovial membrane which covers the superior gleno-humeral ligament. The blending of the tendon, at its origin, with the glenoid ligament should be noted. The capsule may be further incised to any extent necessary to permit of thorough inspection of its deep surface. The openings of the subscapularis and infraspinatus bursæ should be identified, as well as the points of entrance of the articular branches of the suprascapular and circumflex arteries.

The form of the articulating surfaces should be noted and compared with those of the hip-joint as to relative depth of the glenoid and acetabular cavities and rotundity of humeral and femoral heads.

The shallowness of the glenoid cavity and the extensive articulating surface of the humerus are directly related to the relatively wide range of motion of the upper extremity, but this advantage is accompanied by a corresponding sacrifice of the security of the joint. Hence the shoulder-joint is far more liable to *dislocation* than the hip-joint or indeed than any other articulation.

Dislocation may be produced by either direct or indirect violence. Owing partly to the protection afforded against upward displacement by the coraco-acromial ligament, and against anterior and posterior displacements by the tendons in relation

respectively with the anterior and posterior aspects of the joint, the primary displacement is in the downward direction, although the head of the bone, owing to the continuance of the displacing force and the position of the arm at the time, may assume an anterior or a posterior position. Thus, these dislocations are classified as **posterior** or **subspinous,** the head of the bone resting beneath the spine of the scapula; as **inferior** or **subglenoid,** the head of the humerus being palpable in the axilla; and **anterior,** which latter may be either *subcoracoid*, or, if the head of the bone is displaced farther forward, appearing beneath the clavicle at the inner side of the coracoid process, *subclavicular* or *intracoracoid.*

Disease of the shoulder-joint is less frequent than that of many other joints. Various reasons have been cited in explanation of this fact, the most probable appearing to be (1), the laxness of its ligaments, a condition which renders them less liable to injurious strain, and (2) the fact that the movements of the joint are supplemented by the sterno-clavicular and the acromio-clavicular joints, thus diminishing the liability of the articular surfaces to undue compression and mitigating the effects of such compression.

Distention of the capsule in *synovitis* causes more or less enlargement with extensions respectively along the tendon of the biceps in the bicipital groove and into the axilla distal to the border of the subscapular muscle.

In *arthritis* of this joint, pus may burrow beneath the subscapularis,—the subscapular bursa being usually in communication with the joint-cavity,—may follow the musculo-spiral nerve to the outer side of the arm, may burrow along the bicipital groove, or may undermine the deltoid, after having penetrated the capsule, and point anteriorly to that muscle.

The Sterno-Clavicular Joint (Fig. 35).—This **arthrodial** joint (or articulation by reciprocal reception, according to Cruveilhier) includes articular surfaces on the sternal end of the clavicle, on the upper lateral aspect of the manubrium sterni, and on the cartilage of the first rib. The rhomboid impression on the under surface of the clavicle is also implicated but is not a proper articular surface; it is connected by the *rhomboid* or *costo-clavicular ligament* with the first costal cartilage. The other **ligaments** are the *interclavicular*, a single ligament for the joints of the two sides, passing from one clavicle to the other across the upper surface of the sternum; the *anterior* and *posterior sterno-clavicular*, uniting above and below to constitute a *capsule;* and the *interarticular fibro-cartilage* (Fig. 35), a disk with thickened periphery, which divides the joint into two compartments, each lined by its own synovial membrane, and which is sometimes perforated. The range of motion is in almost every direction, though of limited extent. Being the bond of connection between the upper extremity and the trunk, it is of extreme importance in supplementing the movements of the shoulder-joint and of the acromio-clavicular joint.

The dissector should clear away all extraneous tissue from the ligaments. In moving the shoulder in various directions he will note the participation of this joint in these movements and that upward movement of the clavicle is limited by the rhomboid ligament, while downward movement is limited by the interarticular disk and the interclavicular ligament. An incision should now be made through

the anterior ligament exposing the interior of the joint. The posterior ligament should also be divided and an effort made to displace the articular surface of the clavicle, the dissector observing precaution against wounding the underlying vessels. The sternal end of the clavicle should be displaced upward and forward; the force required to effect this affords a good demonstration of the strength and importance of the rhomboid ligament. The form of the articular surfaces should now be noted. It is because of the slight adaptation of these surfaces to each other that dislocations at this joint are apt to recur after displacement.

Dislocations of this joint are relatively infrequent because of the strength of the ligaments, the clavicle usually yielding rather than the ligaments. The direction of the displacement may be either upward, backward or forward, the last being the most frequent.

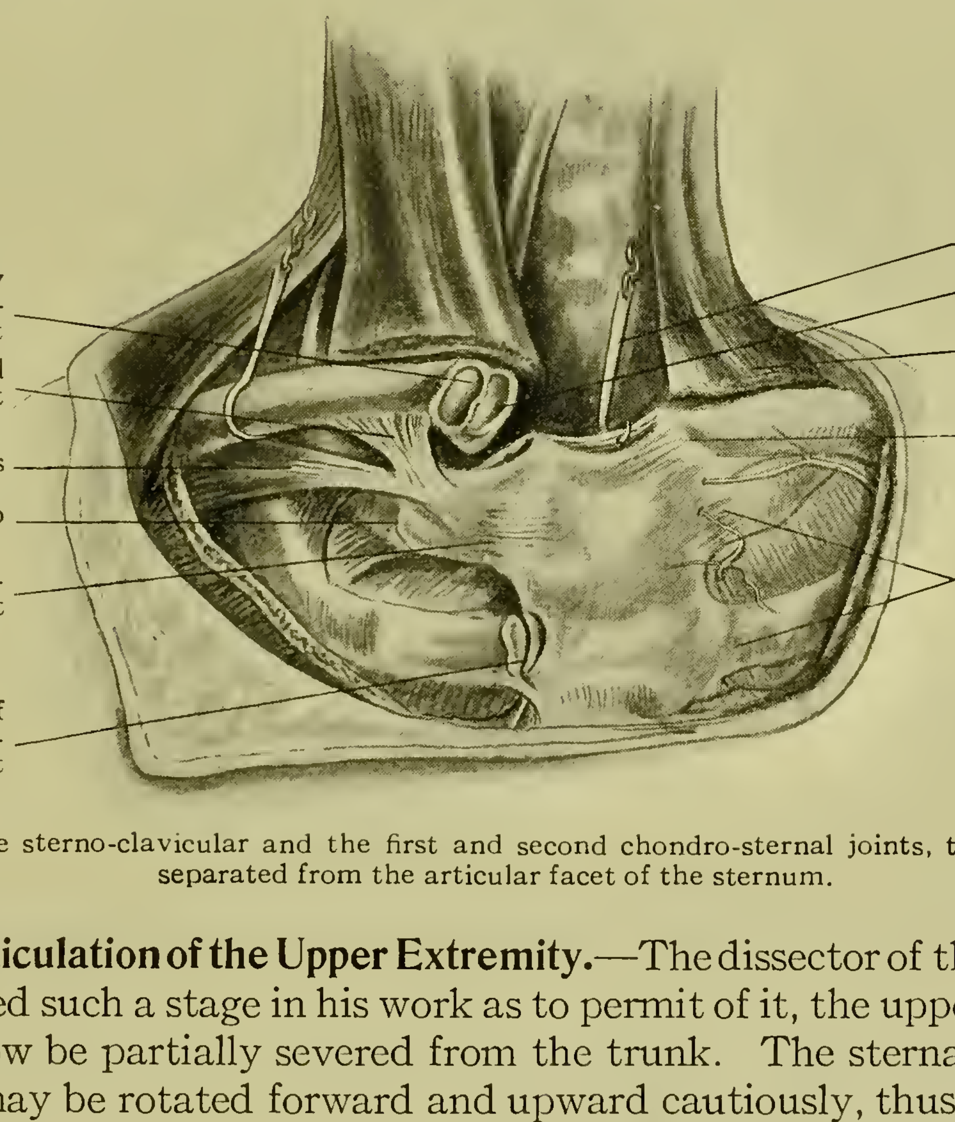

FIG. 35.—The sterno-clavicular and the first and second chondro-sternal joints, the right clavicle separated from the articular facet of the sternum.

Disarticulation of the Upper Extremity.—The dissector of the neck having reached such a stage in his work as to permit of it, the upper extremity should now be partially severed from the trunk. The sternal end of the clavicle may be rotated forward and upward cautiously, thus putting the subclavius muscle on the stretch; this muscle may then be divided close to the first rib; the conoid and trapezoid ligaments may be inspected; the axillary vessels and nerve-trunks may be briefly reviewed and their continuity with the corresponding vessels and nerves of the neck noted, after which they should be divided. Rotating the entire shoulder outward and displacing the contents of the axilla, the serratus magnus muscle will be exposed.

THE SERRATUS MAGNUS MUSCLE (serratus anterior) (Fig. 36).—**Origin,** by nine digitations from the eight or nine upper ribs, the second

rib giving rise to the second and third slips; **insertion,** the ventral surface of the vertebral border of the scapula; **nerve-supply,** the long or posterior thoracic nerve ("external respiratory nerve of Bell") from the fifth, sixth and seventh cervical nerves; **action,** (1) to steady the scapula upon the chest-wall by pulling forward upon its vertebral border, thus opposing the rhomboids, the trapezius and the levator anguli scapulæ in order to afford the scapulo-humeral muscles a more or less fixed point from which to act, and (2), to rotate the inferior angle of the scapula outward

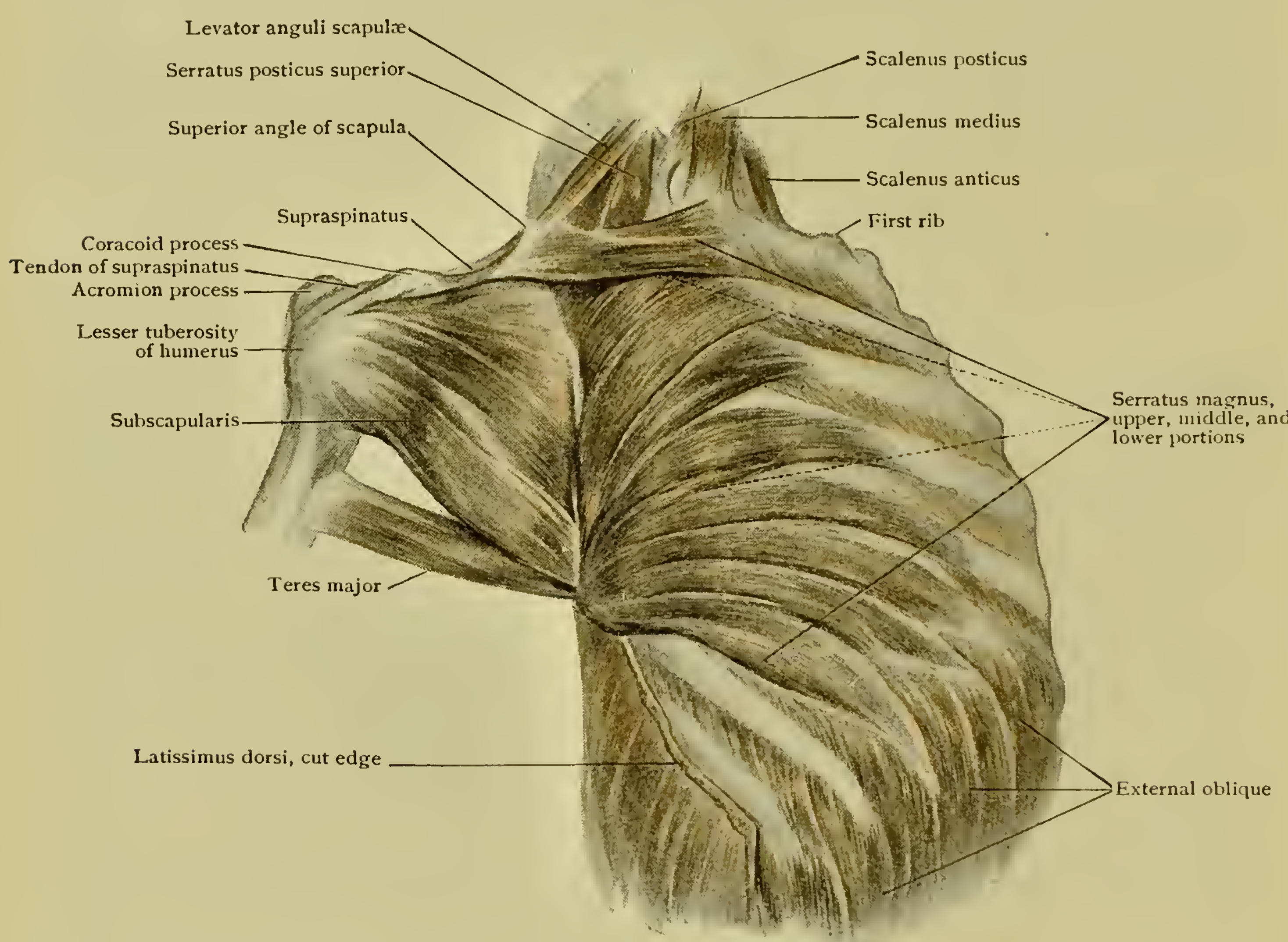

FIG. 36.—Dissection of thoracic wall, showing serratus magnus; clavicle has been removed and scapula drawn outward.

and its superior angle inward in efforts to elevate the humerus beyond the position of a right angle with the trunk, thus augmenting the action of the deltoid and the supraspinatus.

If this muscle has not been cleaned, its covering of rather dense and intimately adherent deep fascia should now be removed, to facilitate which, the muscle should be made tense by carrying the scapula well back. The long thoracic nerve will have been isolated in the dissection of the axilla. The dissector will note that the first and second digitations are inserted into the superior angle of the scapula, the third and fourth into the ventral surface of the vertebral border of its body and the

remaining fibres, comprising the lowest portion of the muscle, into the inferior angle.

The lowest portion of the musele is the most powerful, a fact related to its function in assisting in the action of the muscles which raise the arm (*vide supra*). It will be seen readily that if this muscle be deprived of its innervation by injury or disease of its nerve, the long thoracic, any attempt upon the part of the deltoid and supraspinatus to abduct the arm will result in the rotation of the scapula in a direction opposite to that in which the serratus itself would rotate it, the vertebral border and especially the inferior angle of the bone being made to projeet in a wing-like manner, the condition of so-called "winged scapula." The movements of the arm in this condition would be much impaired.

Having completed the dissection of the muscles and other structures which are related to the shoulder-girdle and to its connection with the trunk on the one hand and the arm on the other, it will be well to consider the anatomical and clinical relations of the bones composing the shoulder-girdle to the structures in question.

The Scapula.—The relation of the scapula to the muscles of its dorsal and ventral surfaces constitutes at once a difficulty in the palpation of the bone (p. 11) in the living subject and a protection against fracture. In practising palpation, the acromion process and the spine are the most easily recognized parts. The coracoid process is usually to be felt in the infraclavicular fossa (p. 29). The superior angle and the vertebral border are rendered obvious by carrying the arm across the front of the chest, while the inferior angle and the lower parts of both vertebral and axillary borders are made prominent by carrying the forearm across the back.

Fractures of the scapula are relatively infrequent for the reason stated above. *Fracture of the acromion process*, the most common form of fracture of the scapula, is not attended with much displacement on account of its dense fascial connections, nor is crepitus a prominent feature of such fracture for the same reason. It may be an epiphyseal separation if occurring prior to the twenty-second or twenty-fifth year. *Fracture of the coracoid process* sometimes occurs, the pectoralis minor, the short head of the biceps and the coraco-brachialis not producing much displacement on account of the strength of the conoid and trapezoid ligaments. An epiphyseal separation may occur here before the seventeenth year. *Fracture of the neck* of the bone (Fig. 9), the smaller fragment including the glenoid cavity and the coracoid process, may not be marked by much displacement if the trapezoid and conoid ligaments are uninjured, but if these ligaments be torn, the resulting downward displacement of the head of the scapula, *i.e.*, the glenoid cavity and the coracoid process, carrying the head of the humerus with them, simulates a downward luxation of the shoulder-joint. The displacement of the coracoid process, however, as well as the unaltered relation between the humeral head and the glenoid cavity, the presence of crepitus and

the ease of reduction serve to characterize the injury as a fracture of the neck of the scapula. *Fracture of the body* of the bone may be obscure as to its signs, since the muscles tend to prevent displacement and the dense supraspinatus and infraspinatus fasciæ tend to prevent the leakage of effused blood toward the surface, thus obscuring what is often an important confirmatory sign of fracture, ecchymosis. Crepitus may often be elicited by placing one hand over the inferior angle of the scapula to fix the lower part of the bone while an assistant moves the patient's arm to bring about motion in the upper fragment.

Disease of the scapula, consisting of *tumors* of various kinds, may necessitate the removal of this bone. Reference to the preceding pages and to Figs. 14, 15, 27, and 33 will sufficiently indicate the structures to be divided in such an operation.

The Clavicle.—Fractures of the clavicle are of more common occurrence than those of any other bone in the body by reason of its slenderness, of its exposed position and of its being the weakest link in the chain connecting the upper limb with the trunk. Fractures due to *direct violence* are usually transverse and may occur at any part of the bone; those caused by *indirect violence* are nearly always at the outer end of the middle third because this is the weakest part of the articulated bone, that is to say, the connection of the outer third of the bone with the coracoid process of the scapula by the trapezoid and conoid ligaments (Fig. 32) and with the acromion process is so intimate as to make it "almost a part of the scapula" (Treves). The line of fracture is oblique in direction, a condition which favors displacement of the fragments. The *displacement* is almost entirely found in the outer fragment, which is displaced (1) *downward,* owing to the weight of the shoulder and to the action of the pectoralis minor pulling upon the scapula, and of the latissimus dorsi and the lowest fibres of the greater pectoral pulling upon the humerus; (2) *inward,* by reason of the action of the pectorals and the latissimus dorsi pulling upon the scapula and the humerus and that of the spino-scapular muscles, the levator anguli scapulæ and the rhomboidei; (3) *backward—as regards the inner end of the outer fragment*—due to the rotation of the shoulder by the action of the serratus anterior upon the vertebral border of the scapula, aided by the two pectorals. If the line of fracture be within the limits of attachment of the subclavius, this muscle will aid in the downward and inward traction upon the outer fragment. The inner fragment is displaced but slightly, being pulled upward by the sterno-cleido-mastoid. If the fracture be of the outer third of the bone, displacement to any considerable degree is prevented by the coraco-clavicular and acromio-clavicular ligaments.

Greenstick fracture is seen more frequently in the clavicle than in any other bone and is often of such slight degree or produces so little deformity as to escape recognition, the obscurity of the signs being

accentuated by the fact that the injury occurs in infants and young children.

The **relations of the clavicle** are of particular interest in connection with *splintered fractures* of this bone as well as with its partial or *complete excision* or *resection*. Beneath the outer part of the middle third, as will have been noted, are the axillary vessels and the brachial plexus, while in close proximity is the acromial thoracic artery, and beneath the inner and middle thirds are the innominate artery and vein, the left common carotid artery (on the left side), the subclavian vein, the internal mammary and suprascapular arteries, the vagus and phrenic nerves, the apex of the lung and the pleura, any one or more of which structures may be wounded by a splinter of bone or in the operation of resection.

The disarticulation of the upper extremity from the trunk may now be completed by dividing the muscles still attached to the vertebral border of the scapula. This disarticulation is not, at this stage, necessary, however, nor is it altogether desirable, since it is rather more convenient to dissect at least the ventral aspect of the upper arm while the member is still attached to the trunk.

THE UPPER ARM.

The Humerus.—Briefly reviewing this bone the dissector will note its **upper extremity** (Fig. 37) as presenting the *greater* and *lesser tuberosities* with their respective areas for muscular attachment, and the *head* of the bone marked off from the tuberosities by the *anatomical neck*. At the **lower extremity** he will note a large articular surface, the *trochlea*, for the greater sigmoid cavity of the ulna, with the *coronoid fossa* (Fig. 37) above it in front and the *olecranon fossa* (Fig. 38) above it behind; the smaller convex articular surface, the *capitellum*, for the head of the radius; the larger *inner condyle* (medial epicondyle) and the smaller *outer condyle* (lateral epicondyle). The **shaft** will be seen to have three borders separating three surfaces. The *anterior border*, beginning at the front of the greater tuberosity, constitutes at first the *outer lip* (pectoral ridge) of the *bicipital groove* and ends below between the capitellum and the trochlea. The *external border* begins at the back of the greater tuberosity and ends below at the outer condyle as the *external supracondylar ridge*, while the *internal border*, starting above near the *inner lip* of the bicipital groove, becomes continuous below with the *internal supracondylar ridge*. The *outer surface*, presenting slightly above its centre the *deltoid eminence*, the *inner surface*, showing the bicipital groove above, and the *posterior surface* with its broad *spiral groove* containing the smaller *musculo-spiral groove*, as well as the muscular areas of these surfaces, should receive due attention.

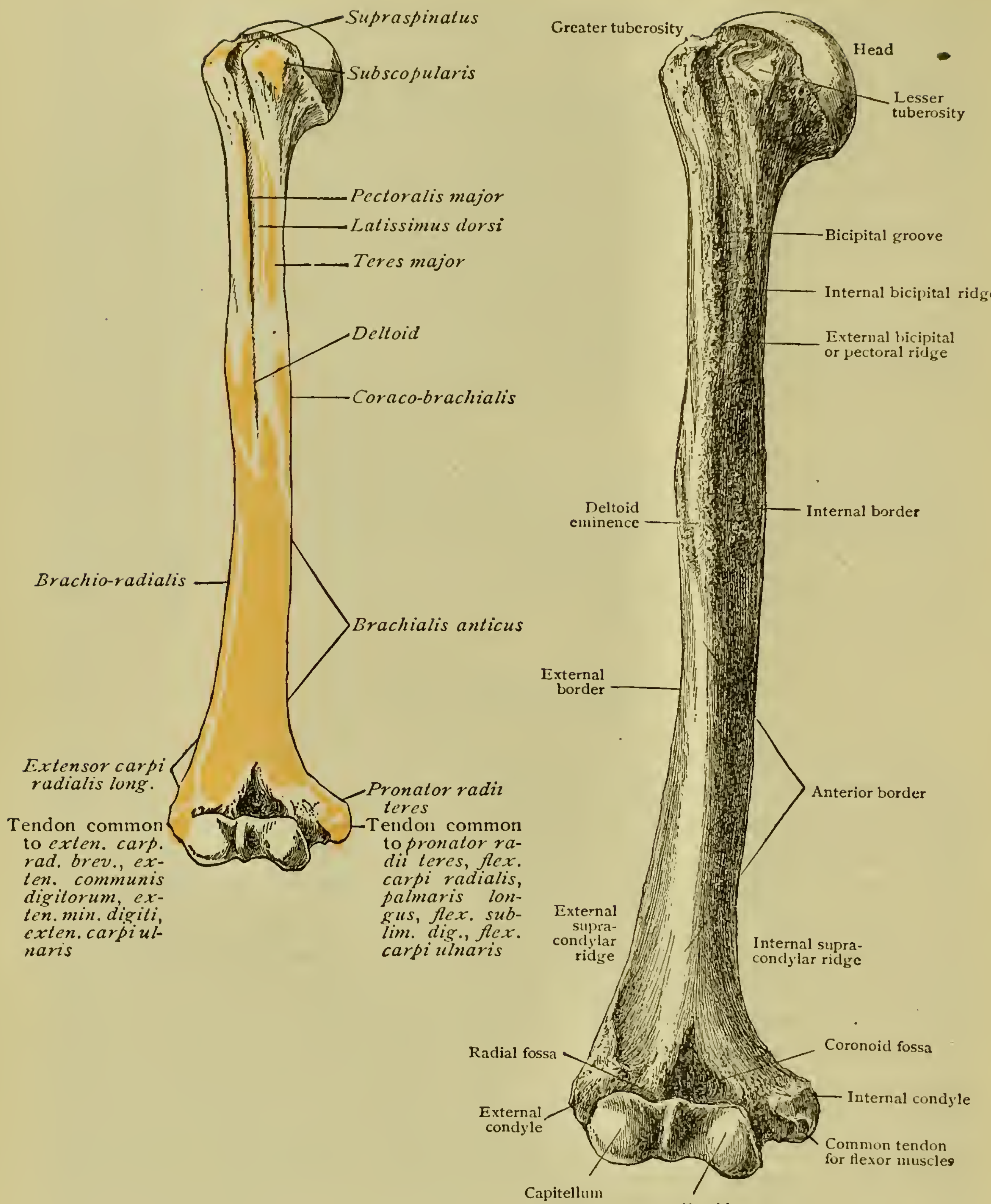

FIG. 37.—Anterior surface of humerus.

THE SURFACE ANATOMY.

The **shaft of the humerus** may be palpated by placing the tips of the fingers and the thumb of one hand respectively on the outer and inner aspects of the arm, nearer the dorsal surface than the ventral. Following the shaft of the bone to its lower extremity it is found to

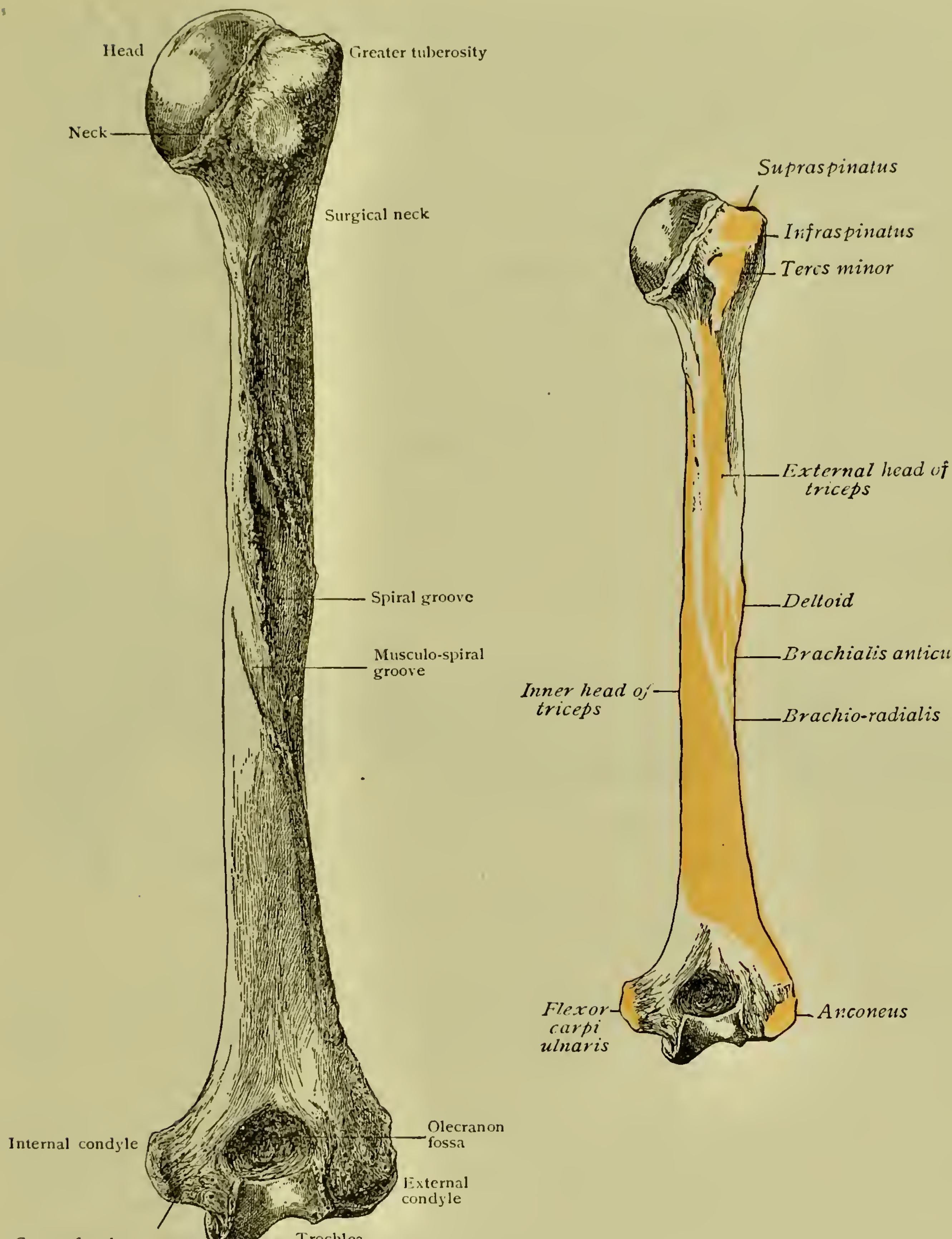

FIG. 38.—Posterior surface of humerus.

become wider, the increase in width being indicated by the **inner** and **outer condylar ridges,** which terminate below at the **inner** and **outer condyles.** Between these prominences, on the posterior aspect of the elbow, the **olecranon process** is palpable.

The swell of the belly of the **biceps** is found on the front of the arm (Fig. 39). Palpating this muscular mass in the living subject, with

the forearm voluntarily semiflexed, the thumb and fingers placed as indicated above, the **tendon of insertion** of the biceps will be felt crossing the front of the elbow-joint, and, passing from the inner border of the tendon, the **bicipital fascia** (Fig. 41) is distinctly palpable as a tense band. Insinuating the tip of the index-finger under the inner border of this fascia at its point of divergence from the tendon, the pulsations of the **brachial artery** may be felt. Immediately to the inner side of the artery the **median nerve** may be rolled beneath the finger, the nerve being identified with certainty by the tingling sensation in the fingers occasioned, in the living subject, by pressure upon it by the palpating finger. Palpating the upper extremity of the belly of the biceps—in the living subject—the arm being held in the horizontal plane and the forearm flexed, the division of the biceps into its two heads may be

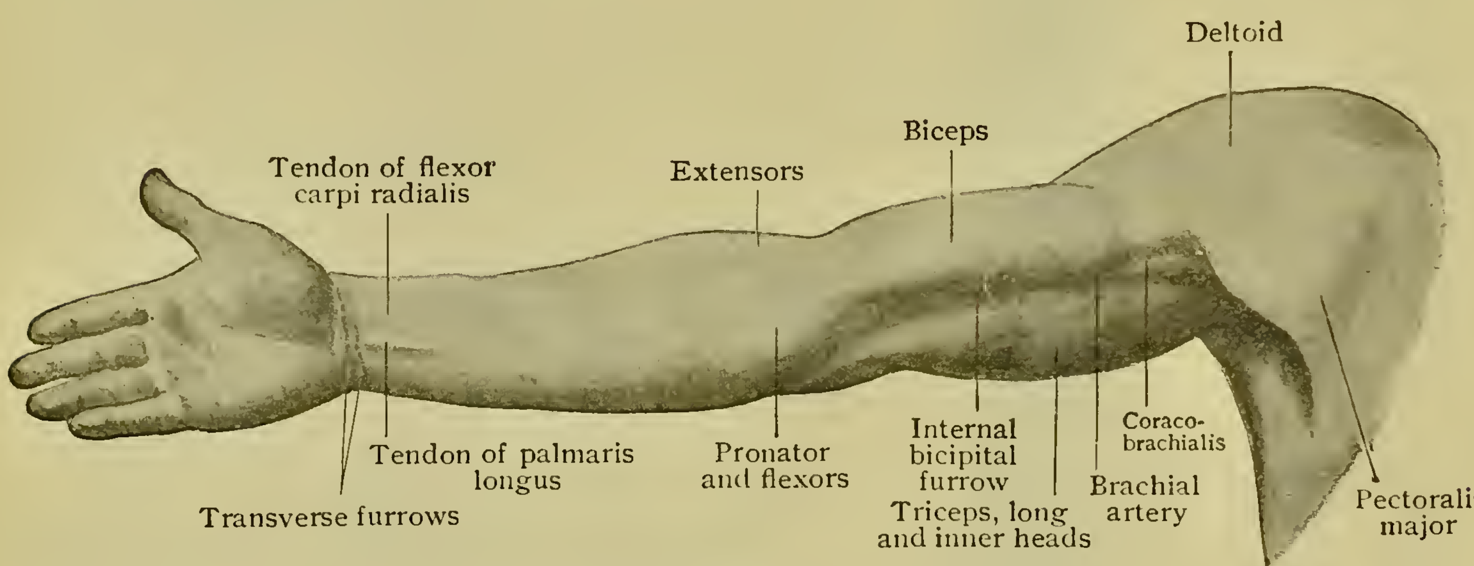

FIG. 39.—Surface anatomy of arm, anterior surface.

made out, this division, as well as the **short tendon,** becoming more evident when the palpating fingers are carried upward to the border of the great pectoral, the tendon of the long head disappearing under that muscle.

Along the outer aspect of the arm will be seen the **outer bicipital furrow** (Fig. 45), corresponding to the interval between the biceps and the triceps. At the upper end of this furrow, at approximately the middle of the humeral shaft, is the **insertion of the deltoid.** The furrow is accentuated by forcible voluntary flexion of the forearm. The **cephalic vein** (Fig. 40) occupies this depression and is sometimes visible through the integument. The **upper** and **lower external cutaneous branches** of the musculo-spiral nerve are also found here.

Along the inner side of the belly of the biceps is the **inner bicipital** or **brachial furrow,** most obvious when the forearm is flexed at an angle of 135 degrees. In the upper half of the arm this surface groove passes back of the coraco-brachialis and becomes continuous with the floor of

the axillary space. The **coraco-brachialis** cannot be differentiated from the short head of the biceps (Fig. 30); its insertion is opposite that of the deltoid. The inner furrow contains a large superficial vein, the **basilic,** as well as the **internal cutaneous nerve.** The fleshy mass behind the furrow is the **triceps.**

On the posterior surface of the arm is the belly of the **triceps,** tapering below into its tendon, which is inserted into the olecranon process of the ulna. With the arm abducted and the forearm in voluntary extension, the long or scapular head of the triceps (Fig. 45) forms a tense ridge leading from the arm to the scapula.

DISSECTION.

A transverse incision should be made across the front of the elbow from condyle to condyle, and a median longitudinal incision, terminating below at the transverse one. The skin-flaps should be dissected from the median incision toward either side of the arm, the dorsal surface not being denuded at this stage. The forearm should be in the position of extension, and care should be exercised to preserve the cutaneous nerve filaments by keeping the cutting edge of the scalpel close to the skin. This exposes the superficial fascia.

THE SUPERFICIAL FASCIA.—This structure is seen to be a rather loose-meshed cellulo-fatty layer, its thickness varying according to the subject. Any small cutaneous veins encountered may be disregarded. The **basilic vein,** a large superficial trunk, appears on the inner side of the biceps in the lower third of the arm, while the **cephalic vein** is seen on its outer side. The **nerves** are cutaneous branches of the internal cutaneous, and the upper and lower external cutaneous branches of the musculo-spiral. To discover the *cutaneous branches of the internal cutaneous nerve* look for the trunk of the latter (Fig. 40) along the inner aspect of the arm, upon the surface of the deep fascia. Slight traction upon the upper part of the trunk where it has been exposed in the dissection of the axilla will facilitate its recognition. The trunk may then be picked up at about the middle of the arm, when the small branches will become evident. The *upper external cutaneous branch of the musculo-spiral nerve* will be found perforating the deep fascia on the outer side of the arm a short distance below the insertion of the deltoid (Fig. 40). Several inches below this, one or several branches of the *lower external cutaneous branch* of the musculo-spiral pierce the deep fascia, the trunk of this nerve continuing to the forearm. In searching for these cutaneous nerves, it is to be remembered that filaments of such size as to be macroscopically recognizable usually lie directly upon the deep fascia.

The dissection of the skin-flaps may now be continued so as to expose the posterior aspect of the arm. If the upper extremity has not been detached from the trunk, the posterior surface may be rendered more

accessible by elevating the arm and placing the flexed forearm across the chest. The *internal cutaneous branch of the musculo-spiral nerve* (Fig. 42) arises at the inner side of the arm, almost immediately after

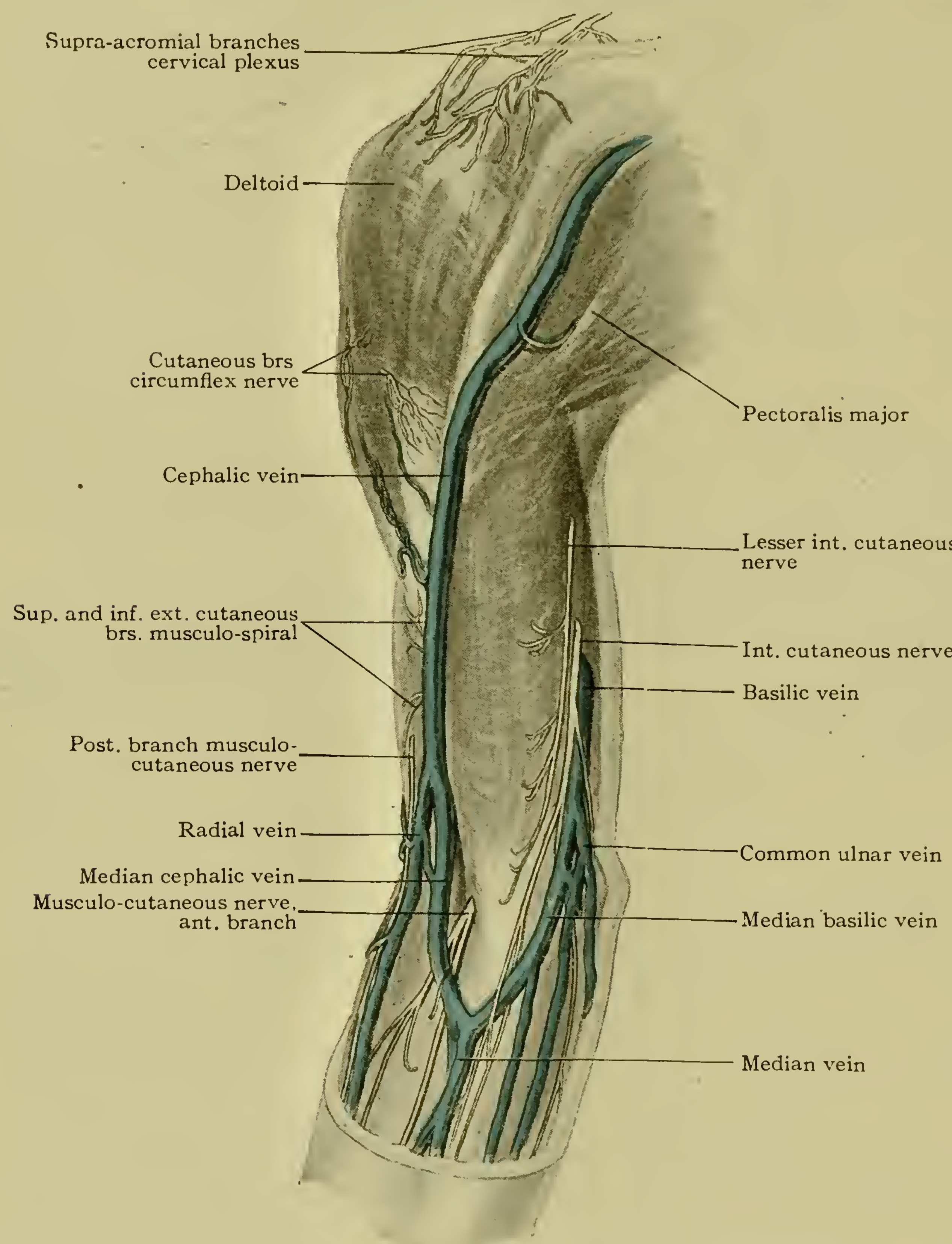

FIG. 40.—Superficial nerves and vessels of anterior aspect of arm.

that trunk leaves the axilla, and courses spirally to the posterior surface, distributing branches to the inner and posterior aspects of the arm. The *lesser internal cutaneous nerve*, which has been encountered in the dissection of the axilla, likewise sends branches to the inner and pos-

terior surfaces of the arm. Associated with it, or sometimes running separately, is the lateral cutaneous branch of the second or third intercostal nerve (Fig. 27).

The isolation of these various cutaneous nerves necessarily mutilates the superficial fascia to such a degree as to render its removal as a continous layer impossible. Its remnants—but not the nerves and veins—should now be cleared away in order to demonstrate the deep fascia.

The looseness of the superficial fascia of the posterior surface of the arm and its freedom from superficial veins of importance explain its frequent selection as a site for the administration of remedies hypodermatically.

The Deep Fascia.—After noting the general features of the deep fascia and the close investment it forms for the muscles of the arm, the dissector should incise it longitudinally over the belly of the biceps and reflect, chiefly by blunt dissection, a flap toward the inner side of the arm. In doing this the biceps will be exposed and then the brachial artery with its accompanying veins and the closely associated median nerve. Proceeding cautiously a little farther inward—still by blunt dissection—the **internal intermuscular septum** will be encountered as a reflection of the deep fascia which is attached to the inner condylar ridge of the humerus and which intervenes between the anterior muscles, the biceps and the brachialis anticus, and the posteriorly situated triceps. As will be seen later, this septum is perforated by the ulnar nerve, the inferior profunda artery and the deep branch of the anastomotica magna artery.

Reflecting now an outer flap of the deep fascia in a similar manner, the **external intermuscular septum** will be revealed as a process of deep fascia attached to the external condylar ridge of the humerus. Separating the triceps from the biceps, the brachialis anticus and the brachioradialis, the septum is seen to be perforated by the musculo-spiral nerve and the anterior branch of the superior profunda artery. The outer flap of fascia may now be replaced, as further consideration of these structures is to be deferred for the present.

The Inner Aspect of the Arm.—Above the lower third of the arm the **basilic vein** will be seen (Fig. 40); traced upward it will be found to unite with the two venæ comites of the brachial artery just below the axilla to form the axillary vein. This basilic vein was encountered in the lower third of the arm, lying superficially to the deep fascia, the point at which it usually perforates the fascia to gain a deeper position being at the upper extremity of the lower third of the arm. Its *origin* is by the confluence of the median basilic and the common ulnar veins (Fig. 40). It is noteworthy as being the largest superficial vein of the upper extremity in point of calibre.

The Ulnar Nerve and Inferior Profunda Artery.—These two structures, bearing each other close company, are found in front of the inter-

nal intermuscular septum in the upper part of the arm, both perforating the septum below the middle of the member. The **ulnar nerve,** traced upward, will be seen to be the largest branch of the inner cord of the

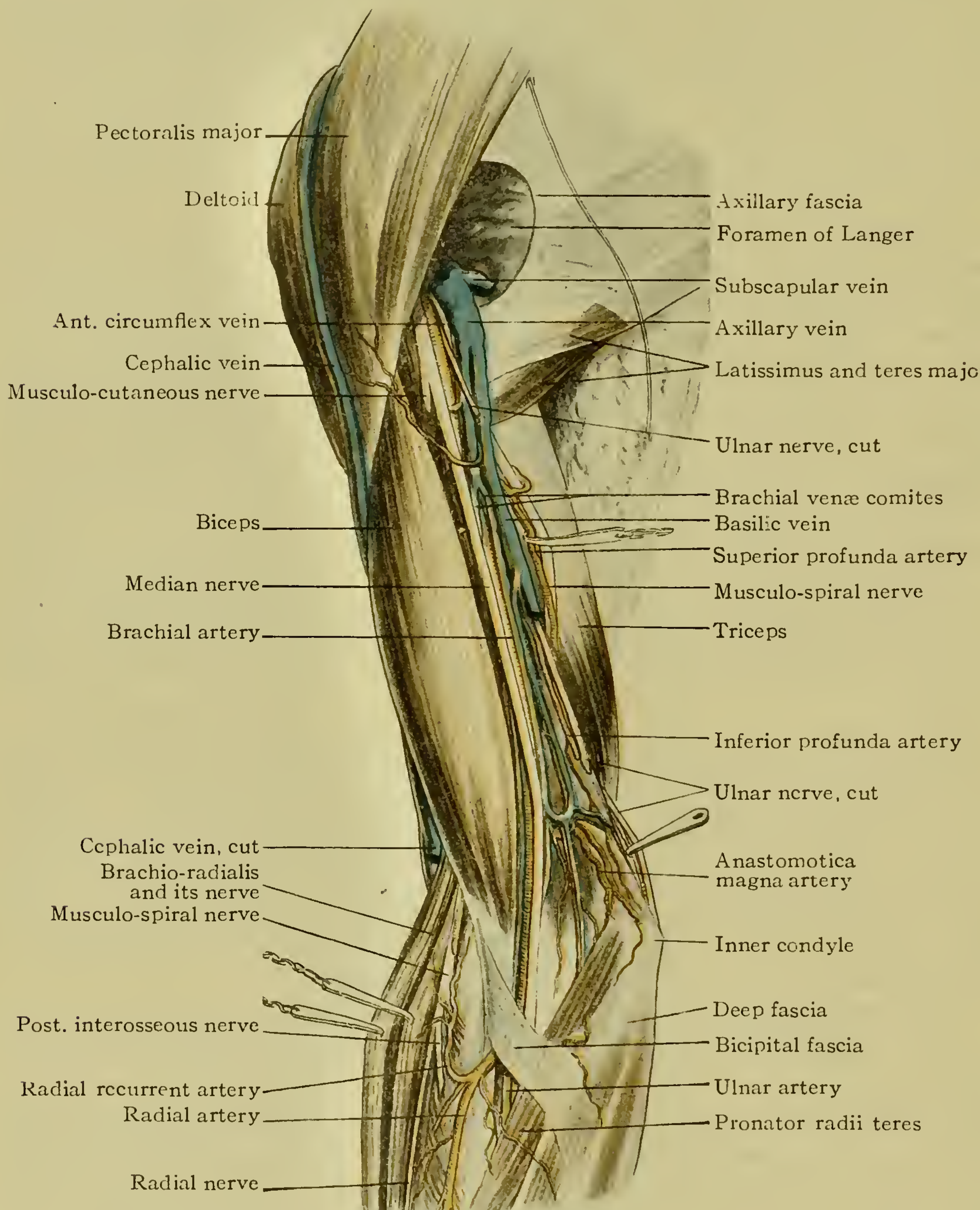

Fig. 41.—Dissection of antero-mesial aspect of arm.

brachial plexus (p. 49). It gives off no branches in the upper arm. The **artery** should be followed upward to its origin from the brachial artery about the middle of the arm. The deep fascia should now be incised

behind the septum and the artery and nerve should be traced toward the inner condyle of the humerus, when it will be seen that the artery ramifies behind that prominence, while the nerve passes through the interval between the inner condyle and the olecranon to pursue its further course in the forearm (p. 113). Upon reaching this interval the dissector should encounter the **posterior ulnar recurrent artery,** a branch of the ulnar artery, which ascends through this space to ramify behind the inner condyle.

The **anastomotica magna artery,** lying in front of the lower part of the inner intermuscular septum, will be easily recognized although usually somewhat masked by areolar and fatty tissue. It should be cleared of connective tissue and traced from its *origin* from the brachial artery at a point about two inches above the elbow to its bifurcation, when it will be seen that one of the branches of bifurcation, the *deep* or *posterior branch*, pierces the intermuscular septum to join with the inferior profunda and the posterior ulnar recurrent behind the inner condyle, while the *superficial branch* anastomoses in front of the condyle with the anterior ulnar recurrent branch of the ulnar artery.

The Median Nerve.—This nerve, the origin of which has been indicated (p. 49) and the course and distribution of which in the forearm and hand will be noted later, bears an important relation to the brachial artery. Lying upon the outer side of this vessel above, it crosses its course at about the middle of the arm, usually passing over but occasionally under the artery, to gain a position upon its inner aspect. The dissector will find the nerve rather closely associated with the vessels, being enclosed with them in a sort of sheath of areolar connective tissue. In removing this tissue one may encounter one or more connecting nerve-trunks or strands, for, though the median nerve distributes no branches in the arm, it sometimes happens that some of its fibre-bundles have joined the musculo-cutaneous nerve, which latter they accompany for a variable distance, sometimes leaving it just prior to its perforating the coraco-brachialis, sometimes as it is in the act of perforating that muscle, and again not until the perforation is completed, to rejoin the parent median trunk. In such case the median nerve presents the appearance of having acquired a bundle of fibres from the musculo-cutaneous, which bundle may or may not pierce the coraco-brachialis wholly or in part.

The Brachial Artery (Fig. 41).—The position of this vessel will be indicated by its **surface line,** *i.e.*, a line drawn from the middle of the clavicle or from the junction of the anterior and middle thirds of the floor of the axillary space to the middle of the bend of the elbow, the arm being abducted to such extent as to form a right angle with the trunk. Its course is therefore along the inner side of the biceps and the coraco-brachialis, which muscles are for this reason called the *muscles*

of reference. Followed upward to the lower border of the tendons of the latissimus dorsi and teres major, the artery is seen to have its **origin** in the axillary artery, being the continuation of that vessel, while it **terminates** by bifurcating, in the antecubital fossa, into the radial and ulnar arteries. Variations of this arrangement may occur. Instead of the bifurcation in the antecubital fossa, there may be a high bifurcation of the brachial, which may occur just beyond the limits of the axilla or in the axilla, or further down the arm. In such case, two large arterial trunks will be found in the arm instead of one, one of which represents the brachial, giving off the branches usually arising from that vessel, while the other represents the radial or the ulnar.

The brachial artery should be divested of its investing connective tissue, due care being exercised to preserve its branches, as well as the venæ comites or accompanying veins.

The **branches** of the brachial are the *superior profunda* (Fig. 42), which accompanies the musculo-spiral nerve spirally around the posterior and outer aspects of the arm; the *nutrient*, which supplies the humerus, entering this bone on its anterior aspect about opposite the insertion of the deltoid; the *inferior profunda* and the *anastomotica magna*, the origin and courses of which have been indicated above; and some unnamed *muscular* branches. These various branches should be isolated and cleaned, the nutrient being followed to the point where it enters the bone; the superior profunda, at this stage, may be followed for only an inch or two of its course.

The **relations of the brachial artery** (Fig. 42) should be carefully noted now that the student has completed its dissection. Note first that it passes along the inner aspect of the coraco-brachialis and the short head of the biceps in the upper half of the arm, then along the inner side of the belly of the biceps, resting upon the brachialis anticus, to cross the front of the elbow-joint in close relation with the inner side of the biceps tendon, in which latter relation it lies under the bicipital fascia. Behind the upper half or two thirds of the artery is the triceps.

On account of this relation of the triceps it is desirable in operation upon the artery to support the elbow in such manner as to leave the posterior aspect of the arm free, since otherwise the fleshy mass of the triceps is pushed forward and so disturbs the natural relations of the parts.

The median nerve is external to the artery above, and internal below, the nerve crossing the vessel superficially usually, though sometimes passing under it, about the middle of the arm. The ulnar nerve and the internal cutaneous nerve are internal to the vessel, the relation being rather close above but more remote below, their course diverging from that of the artery.

The **venæ comites** or **accompanying veins** of the brachial artery are usually two in number, one on each side of the artery. The dissector

will have discovered the intimacy of their association with the artery by means of the common connective tissue investment and will appreciate that this relation renders the ligation of the artery in the living subject more difficult. Further embarrassment in such operation may

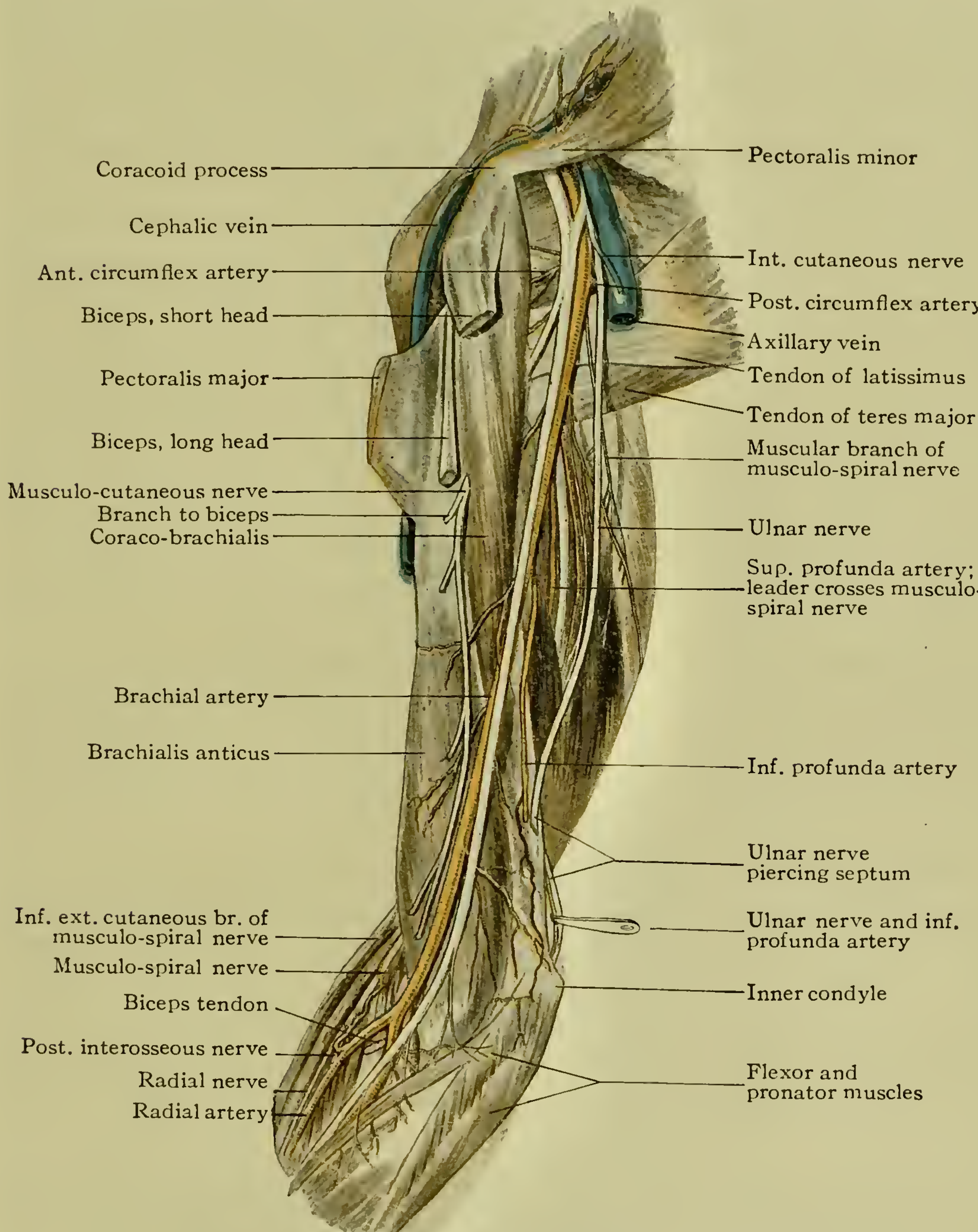

FIG. 42.—Deep dissection of antero-medial surface of arm.

be caused by the numerous communications between the two venæ comites. These veins are continuations of the deep veins of the forearm, the radial and the ulnar, and unite with the basilic vein to form the axillary in the lower part of the axilla or the upper part of the arm. The

arrangement of these veins is subject to variation. Sometimes there will be a single vein; again, the two may unite at some point below the axilla to form a single trunk which then joins the basilic; or the union of one or both with the basilic may occur earlier or later than usual.

THE OUTER ASPECT OF THE ARM.—Reflecting again the outer flap of deep fascia already dissected, the dissector will note the external intermuscular septum and its attachment to the outer condylar ridge of the humerus. At the upper part of this septum a large nerve-trunk perforates it, the musculo-spiral, accompanied by an artery, the anterior terminal branch of the superior profunda.

The musculo-spiral nerve may be difficult to discover at first, appearing as a faintly defined band upon the anterior surface of the membrane. It should be picked up with forceps and traced downward through the interval between the brachialis anticus and the brachio-radialis muscles (Fig. 42), the muscles being cautiously pushed apart for the purpose. The dissection of this nerve should be done with due regard for the arteries of this region. The nerve in this intermuscular interval divides into its two terminal trunks, the *radial* nerve (the more externally situated trunk) and the *posterior interosseous* nerve. In this situation the nerve also gives *muscular branches* to the brachialis anticus and to the brachio-radialis. The radial and the posterior interosseous nerves will be further studied in the dissection of the forearm.

The **anterior branch of the superior profunda artery,** found in this intermuscular space, anastomoses with the recurrent radial branch of the radial artery, which ascends from the forearm. This anastomosis constitutes the circulation in front of the outer condyle and is demonstrable only in highly successful injections, quite commonly being absent in the ordinary dissecting-room material.

That part of the brachialis anticus (Fig. 52) which is adjacent to the brachio-radialis should now be examined to bring to light the **cutaneous branch of the musculo-cutaneous nerve** (Fig. 52), which emerges from beneath the outer border of the biceps at its lower part to pursue its course to the radial side of the forearm. Turning now to the brachio-radialis muscle (Fig. 54), its attachment to the upper two thirds of the outer condylar ridge should be worked out. The narrower muscle partly overlapped by it, and which is attached to the lower third of the ridge (Fig. 55), is the long radial extensor of the wrist. Passing above the limits of the condylar ridge, the dissector will note a whitish line passing up to the insertion of the deltoid which indicates the outer limit of the origin of the brachialis anticus (Fig. 44) and the anterior limit of the insertion of the triceps. The insertion of the deltoid and further up and more anteriorly that of the great pectoral should be examined.

THE ANTERIOR ASPECT OF THE ARM.—The muscles on this surface of the arm will have been partially cleaned in dissecting the structures

previously mentioned. Any remaining connective tissue should be removed, the arm being abducted and the forearm extended.

THE BICEPS CUBITIS.—**Origin,** the *long head,* tendinously, from the supraglenoid tubercle of the scapula, the tendon perforating the capsular ligament of the shoulder-joint but being excluded from its synovial

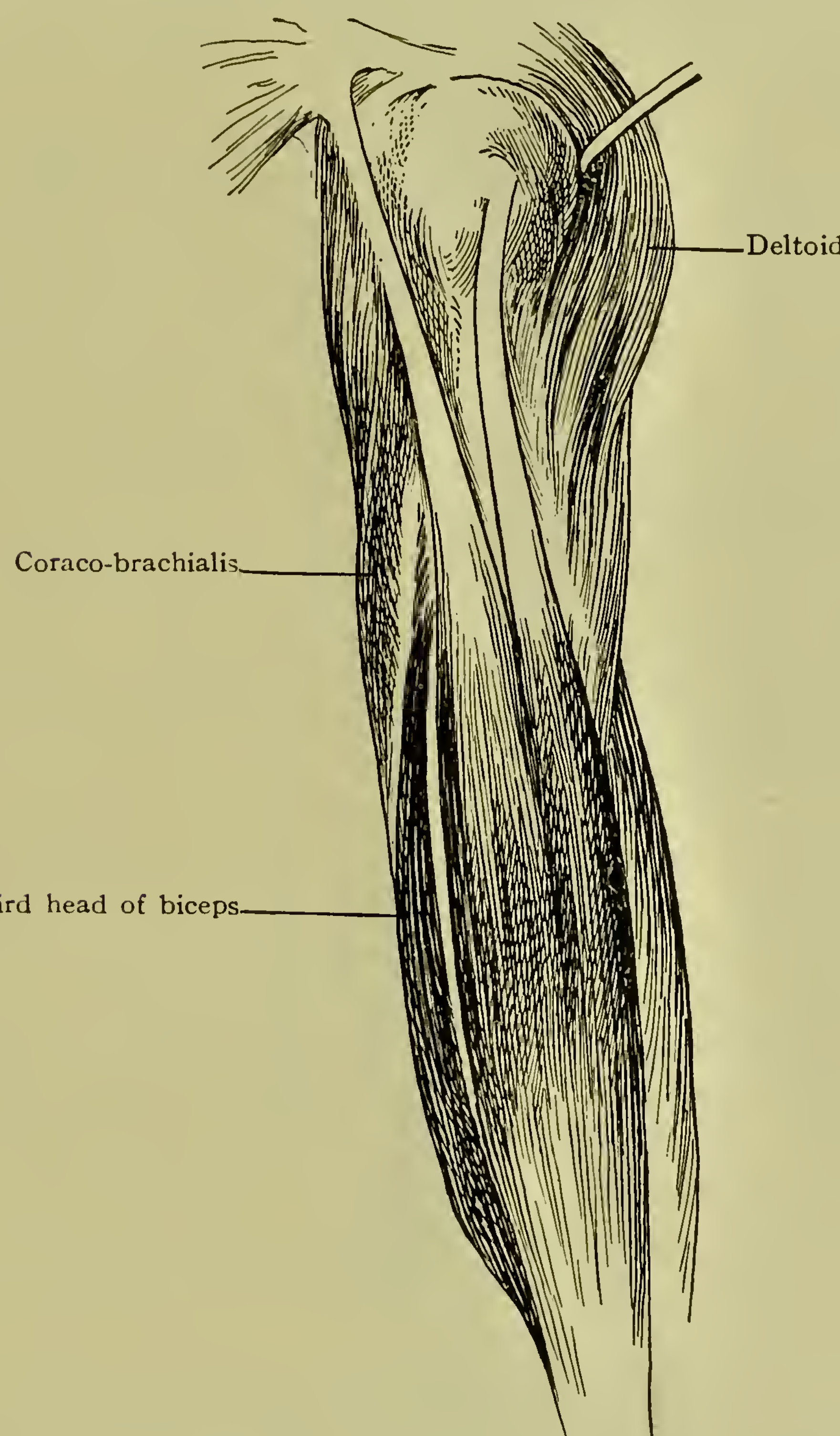

FIG. 43.—Dissection showing three-headed biceps of left side. Drawn from a photograph of a dissecting-room preparation.

cavity, after which it passes between the two tuberosities of the humerus to traverse the bicipital groove of that bone; the *short head,* tendinously, from the scapular coracoid process in common with the coraco-brachialis; **insertion,** tendinously, into the bicipital tuberosity of the radius, a bursa intervening between the tendon and the anterior portion of the

tuberosity; **action,** primarily flexion, secondarily supination of the forearm; **nerve-supply,** from the fifth and sixth cervical nerves through the musculo-cutaneous nerve. *Variations* in the biceps are met with, consisting in the absence of the long head, or, more frequently, the presence of additional heads, an example of the latter being shown in Fig. 43, where a third head arises from the humerus between the insertions of the deltoid and the coraco-brachialis, a variant form which is said to occur once in ten cases.

The long head may be followed to its origin. The relation of the long tendon to the shoulder-joint has been demonstrated (Fig. 34). Its relation to the bicipital groove should be examined, and its passage under the transverse ligament to enter that groove should be noted. As stated above, this tendon within the capsule of the shoulder-joint receives an investment of synovial membrane which shuts it out from the synovial cavity, this synovial sheath being prolonged a variable distance along the bicipital groove. Raising the tendon from the groove, one may find an arterial twig from the anterior circumflex passing up to the joint. The very close relation between the short head and the coraco-brachialis muscle should be noted. The tendon of insertion cannot be examined *in toto* at this stage of the dissection. The bicipital fascia, continued from the inner border of the tendon to spread out fan-like into the deep fascia of the forearm, should be dissected and preserved (Fig. 41).

The belly of the biceps should be cautiously separated from the underlying structures by blunt dissection, beginning at the outer border, which should be raised gradually and cautiously lest the underlying musculo-cutaneous nerve be injured. After having worked along with the scalpel handle until the nerve is recognized—usually somewhat nearer the inner than the outer border of the belly—the inner edge of the muscle may be raised and detached in like manner, and with like caution so as to avoid tearing the branch or branches of the nerve which supply the biceps. The muscle should be elevated upon the hand to demonstrate its lack of connection with the humerus. Now either invert the muscle or hold it aside to expose the brachialis anticus muscle and the musculo-cutaneous nerve.

The belly of the biceps is sometimes *partially ruptured* by excessive muscular action, a condition evidenced by a transverse groove as well as by impairment of the function of the muscle. The tendon of insertion is subjeet to *sprain*, as are also to a less degree the tendons of origin. *Inflammation of the bursa* in relation with the tendon of insertion may cause great pain on motion and consequent interferenee with flexion and supination of the forearm. The sheath of the tendon of the long head is sometimes the seat of *thecitis*.

The Musculo-Cutaneous Nerve.—The *origin* of this nerve is given above. The trunk of the nerve followed upward will be seen to emerge from the coraco-brachialis, which it perforates, and to which it supplies

a branch. Followed downward, it is found to give one or more branches to the biceps upon its deep surface, and one or more branches to the superficial surface of the brachialis anticus. The **cutaneous division** of the nerve then emerges from beneath the outer border of the biceps

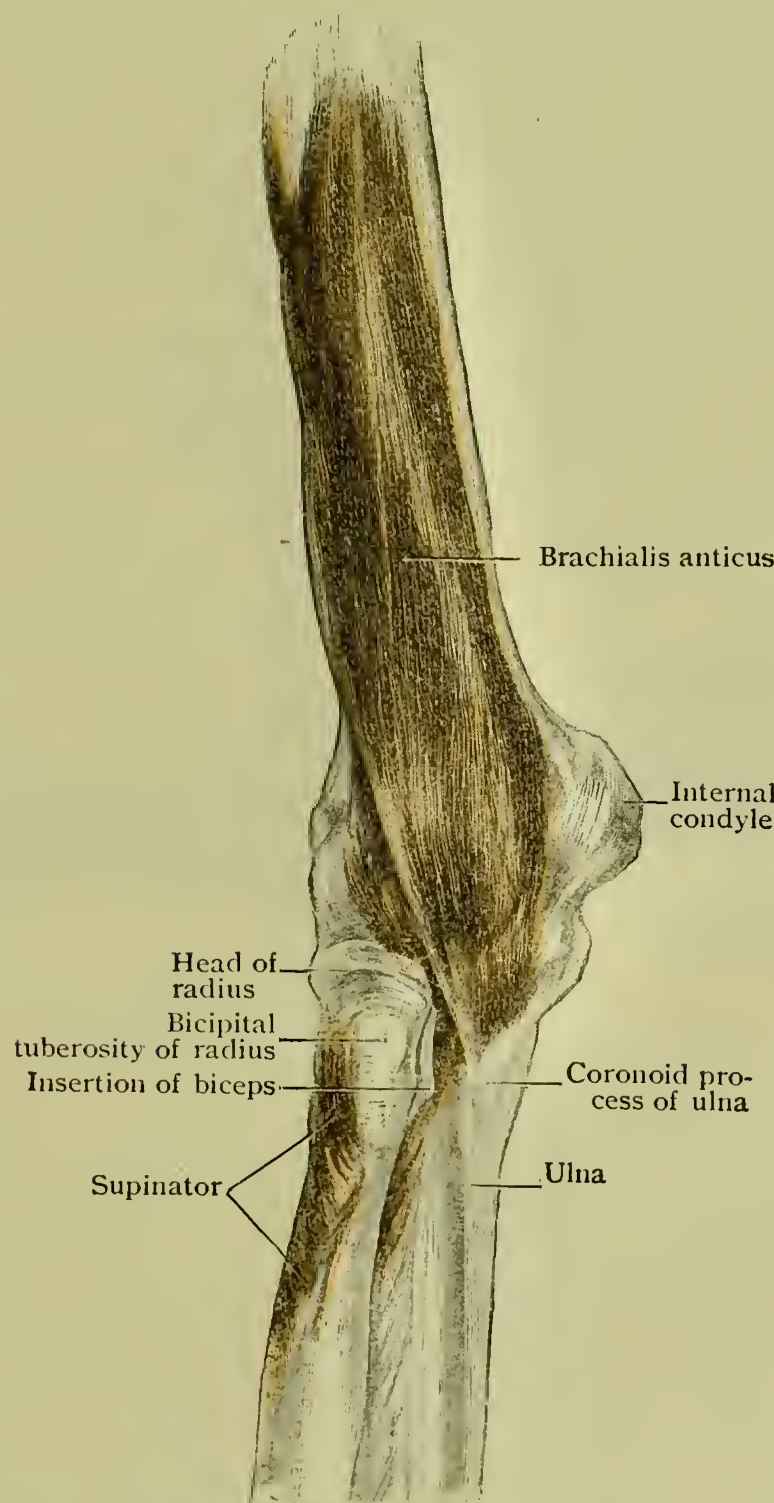

Fig. 44.—Brachialis anticus and supinator, seen from in front.

just above the elbow (Fig. 40) and passes to the radial side of the forearm, dividing into an *anterior* and a *posterior branch* for the supply of the integument on the anterior and posterior aspects of the radial side of the forearm respectively. It also sends a branch to the elbow-joint. To repeat, the **distribution** of the musculo-cutaneous nerve is

to the coraco-brachialis, the biceps, a part of the brachialis anticus, the elbow-joint and the skin of both aspects of the radial side of the forearm. These various branches, except those pertaining to the forearm, should be isolated as a preliminary to the dissection of the brachialis anticus.

The Coraco-Brachialis (Fig. 27).—**Origin,** the scapular coracoid process in common with the short head of the biceps; **insertion,** the shaft of the humerus, about the middle, on the inner border; **action,** to adduct the arm; **nerve=supply,** from the fifth cervical nerve through the musculo-cutaneous.

The dissection of this muscle presents no difficulties. Its noteworthy features are its relation to the brachial artery and its perforation by the musculo-cutaneous nerve.

The Brachialis Anticus (Fig. 44).—**Origin,** the lower half of the anterior surface (or, more accurately, of the inner and outer surfaces)

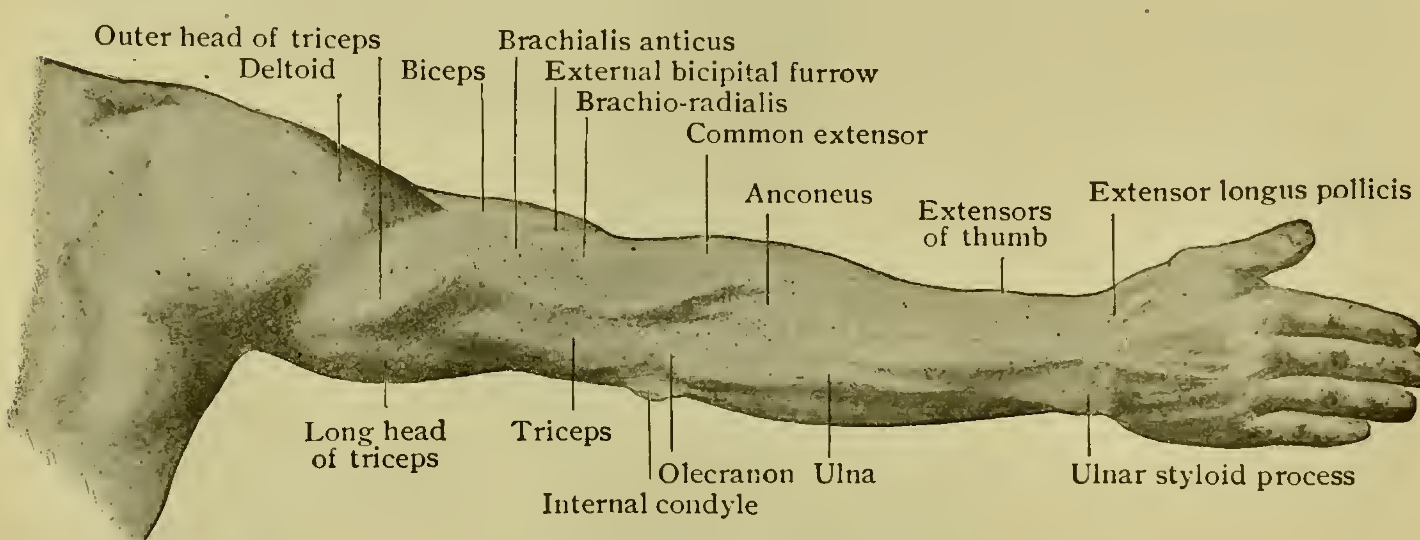

Fig. 45.—Posterior surface of arm shown in Fig. 39.

of the shaft of the humerus, embracing the insertion of the deltoid, and from the intermuscular septa; **insertion,** the anterior surface of the coronoid process and the adjoining portion of the shaft of the ulna; **action,** flexion of the forearm; **nerve=supply,** from the sixth and seventh cervical nerves through the musculo-spiral and the musculo-cutaneous.

The lower portion of this muscle cannot be dissected until the structures contained within the antebrachial fossa have been studied, since it forms the floor of that space. The remaining portion should be denuded, the dissector noting the entrance of the branch of the musculo-cutaneous nerve into the body of the muscle and of that from the musculo-spiral into its lower outer part.

The Posterior Aspect of the Arm.—The superficial fascia and the cutaneous nerves of this region having been dissected, the deep fascia is now exposed. It presents no features of special interest other than those already indicated as pertaining to the deep fascia of the arm in general. Sharply flexing the forearm, the deep fascia should be

removed. A median longitudinal incision having been made, it may be dissected toward either side of the arm to the intermuscular septa. It will thus appear that this part of the deep fascia, with the septa, forms a compartment for the posterior muscle, the triceps.

THE TRICEPS (Fig. 47).—**Origin,** the *long* or *scapular head*, tendi-

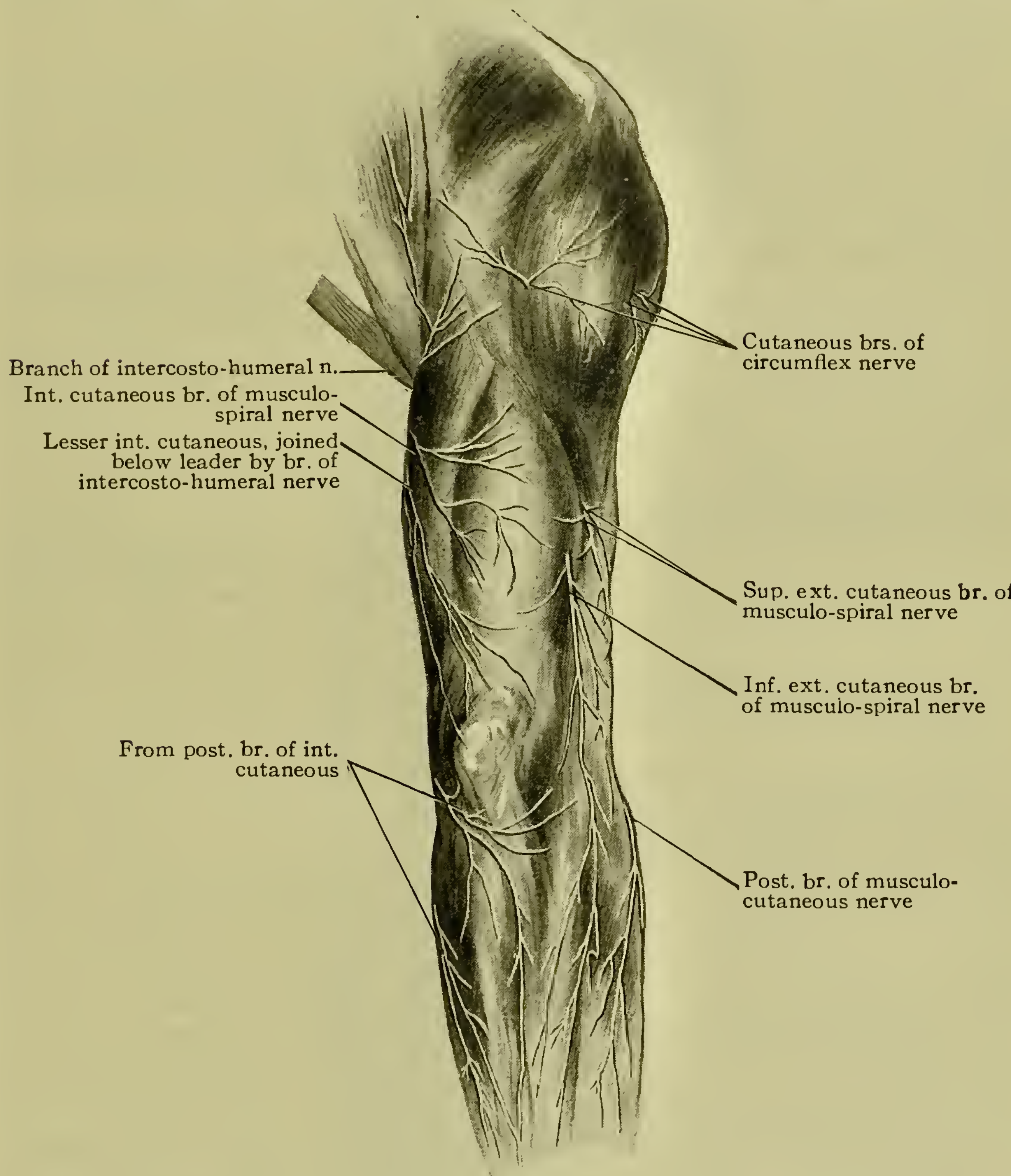

FIG. 46.— Superficial dissection of right arm, showing cutaneous nerves of posterior surface.

nously, from the infraglenoid tubercle of the scapula; the *inner* or *medial head* from the dorsal surface of the shaft of the humerus internal to the musculo-spiral groove and from both intermuscular septa; the *outer* or *lateral head* from the dorsal surface of the humerus lateral to the musculo-spiral groove and from the external intermuscular septum;

insertion, by its tendon into the olecranon process of the ulna, expansions passing from the borders of the tendon to blend with the deep fascia of the forearm; **action,** to extend the forearm and to draw the entire arm backward; **innervation,** the sixth, seventh and eighth cervical nerves through the musculo-spiral. A variation may present in the form of an additional head of origin from the scapular coracoid process or from the shoulder-joint capsule.

The surface of the muscle should be cleaned and the heads should be separated by the handle of the scalpel. In the interval between the inner and outer humeral heads will be found the musculo-spiral nerve and the superior profunda artery, winding spirally around the humerus from above downward and from within outward.

The Musculo-Spiral Nerve.—The origin of this nerve has been indicated on p. 47. It should be picked up in the axillary space and followed in its course around the humerus as it traverses the musculo-spiral groove of that bone. The **branches** are the *internal cutaneous*, the *upper* and *lower external cutaneous*, the *muscular* and the *terminal branches*, the *radial* and *posterior interosseous*. Beginning at the outer limit of the axilla, the **internal cutaneous branch** (p. 46 and Fig. 42) and the **internal muscular branches** to the inner and the long heads of the triceps are found; they may arise by a common trunk. The muscular branch to the inner head, the *ulnar collateral nerve*, is long and slender, passing down as far as the lower third of the arm. In cleaning the musculo-spiral nerve as it winds around the humerus (Fig. 47) care must be exercised to avoid injuring the accompanying superior profunda artery and its branches.

On the posterior aspect of the humerus will be found the **posterior muscular branches** to the inner and outer heads of the triceps. To expose these, the long head of the muscle must be either pulled to one side or cut, preferably the former. One of these branches may be followed down through the substance of the triceps to its termination in the anconeus muscle (Fig. 47). As the trunk is followed toward the outer side of the humeral shaft, the *upper external cutaneous branch* will be found and a few inches further along the *lower external cutaneous*, already referred to on p. 73 as being distributed respectively to the skin of the lower half of the front of the arm and the skin of the dorsal surface of the radial side of the forearm. Both pierce the outer head of the triceps.

Following the musculo-spiral trunk still further the dissector will note its perforating the external intermuscular septum and its giving off the **external muscular branches** to the brachio-radialis, the extensor carpi radialis longior and the outer part of the brachialis anticus, as well as one or two **articular filaments** to the elbow-joint. It then divides into two terminal branches, the *dorsal interosseous* and the *radial*, which will be dissected with the forearm.

It is apparent therefore that the *muscular distribution* of the musculo-spiral nerve in the upper arm is to the great extensor of the forearm, the triceps, to an auxiliary extensor, the anconeus, to a part of one of

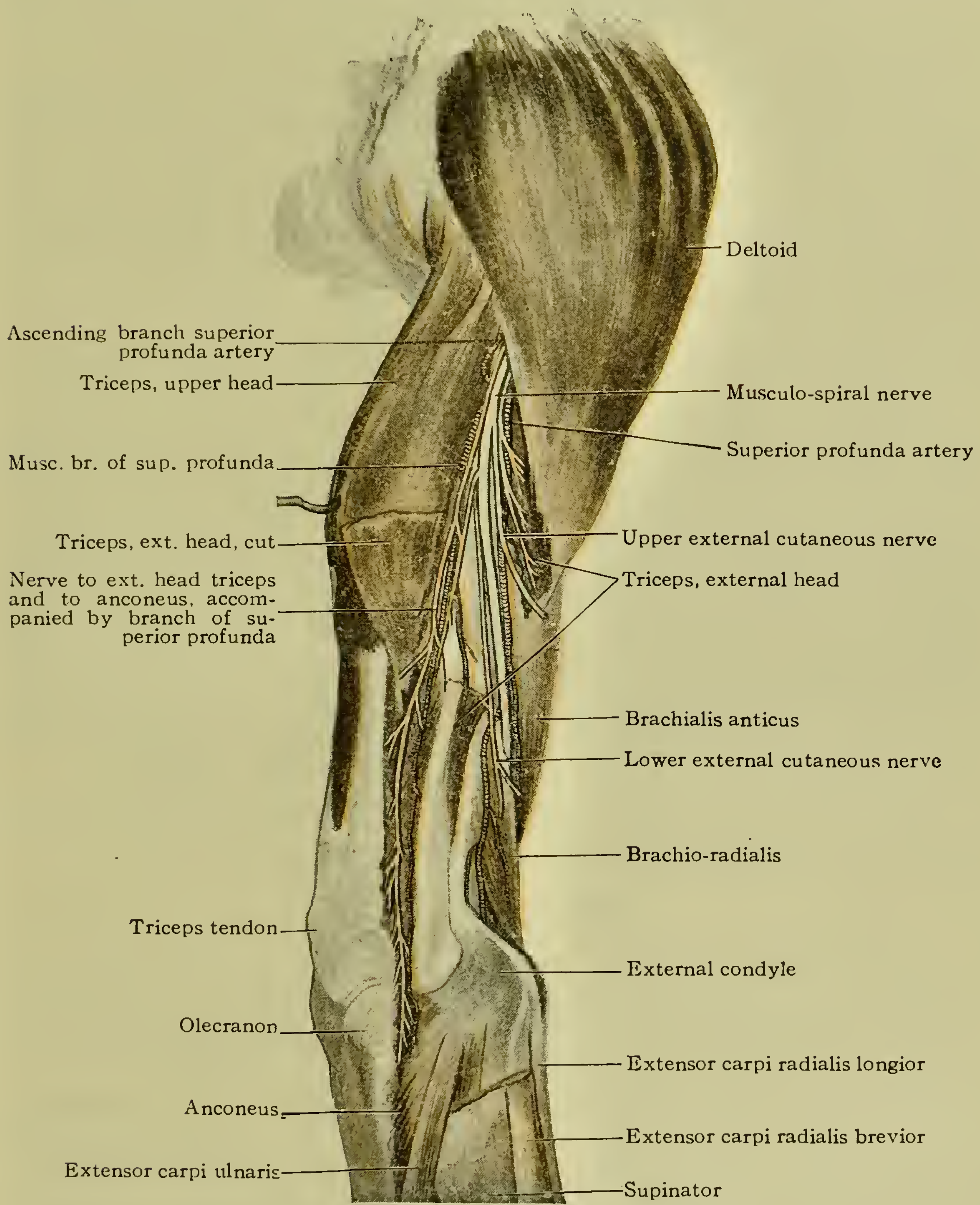

FIG. 47.—Dissection of posterior aspect of arm.

the great flexors of the forearm, the brachialis anticus, and to a muscle which acts as a supplemental flexor, the brachio-radialis; while its *cutaneous distribution* is to somewhat limited areas on the dorsal and outer aspects of the arm.

The proximity of the musculo-spiral nerve to the shaft of the humerus renders it liable to traumatism in several ways: it may be compressed against the bone by blows or other violence or may be severed, as by the bite of a horse; it may be torn or punctured by a spicule of bone in fracture of the humerus; it may be surrounded and pressed upon by callus during the healing of a fracture. Any one of these forms of violence may cause either irritation or paralysis of the nerve, according to the degree of injury.

The Superior Profunda Artery. — In dissecting the musculo-spiral nerve, the superior profunda artery will have been at least partially dissected. Its dissection should now be completed, beginning at its *origin* from the brachial at the upper inner part of the arm. Near its origin, one of its larger branches, the *tricipital*, arises and passes upward between the outer and long heads of the triceps to anastomose with the posterior circumflex branch of the axillary.

This anastomosis plays an important part in establishing the collateral circulation after ligation of the brachial artery above the origin of the superior profunda.

Numerous *muscular branches* of the profunda enter the triceps, constituting the vascular supply of that muscle, and a *nutrient branch* enters the humerus near the upper end of the musculo-spiral groove. Following the artery to the outer side of the arm, it will be seen to divide into two *terminal branches*, one of which, the *anterior*, pierces the external intermuscular septum as indicated on p. 80; the other, the *posterior branch*, of much larger size, ramifies behind the outer condyle of the humerus, anastomosing with the interosseous recurrent from below and the anastomotica magna and the inferior profunda from the inner side of the joint. These anastomoses should be worked out as well as the stage of the dissection and the condition of the vessels will permit.

These vascular communications will come into play when the brachial artery is tied or otherwise obstructed below the giving off of its chief named branches.

THE HUMERUS.

Having completed the dissection of the upper arm, the advanced student should note certain features of its structure and development as well as the relations of the muscular structures to the shaft of the humerus, and especially the places of insertion of the muscles.

The head of the bone may be separated from the shaft by a **fracture of the anatomical neck,** the shallow constriction which divides the head from the tuberosities, an injury which occurs in old people owing to structural changes incident to their time of life. If such a fracture is complete and unimpacted and is attended with extensive tearing of the capsular ligament, the head will undergo necrosis owing to deprivation of its blood-supply.

The upper epiphysis of the humerus, including the head and the tuberosities, is ossified from two or three centres, which appear succes-

sively between the time of birth and the end of the third year and which co-ossify to form a single bony mass by the fifth year. This epiphysis unites with the diaphysis or shaft at the age of nineteen, its line of union corresponding with an approximately transverse line immediately below the great tuberosity. An **epiphyseal separation** due to violence—as by forcible outward and upward traction—may therefore occur prior to the age of nineteen. The displacement tends to be restricted by the manner in which the cup-shaped lower end of the epiphysis is fitted upon the conical end of the diaphysis. Whatever displacement does occur is due to the inward pull of the great pectoral, the teres major and the latissimus dorsi, which are inserted upon the lower fragment.

The **surgical neck** is frequently the seat of fracture. Although the direction and degree of resulting displacement will be influenced by the particular form of violence that produces the fracture and consequently by the direction of the line of fracture, the action of related muscles is important and should be considered. Shortening will be produced by the biceps, coraco-brachialis, triceps and deltoid acting upon the lower fragment. The lower fragment is further displaced by the action of the great pectoral, the teres major and the latissimus dorsi, which pull its upper end toward the chest-wall, and by the deltoid, which, pulling upon its point of insertion near the middle of the shaft, favors the action of the muscles mentioned by tending to abduct the elbow. The upper fragment tends to be abducted by the supraspinatus, its rotation to any considerable extent being prevented by the action of the subscapularis, attached to the lesser tuberosity, opposing the infraspinatus and the teres minor, which are inserted into the greater tuberosity.

The **shaft** of the humerus is most liable to fracture near its middle on account of certain peculiarities of form and structure—the curvature of the shaft, the small size at this point and the greater density and consequent lack of elasticity. In *fractures above the insertion of the deltoid*, shortening of the arm is produced by the biceps, coraco-brachialis and triceps, and the upper end of the lower fragment is drawn upward and outward by the deltoid, while the lower end of the upper fragment is drawn inward by the latissimus, the teres major and the great pectoral, these being of sufficient power to counteract the abducting action of the supraspinatus. In *fracture below the deltoid insertion*, shortening will be due to the factors named in the last case, while the abducting action of the deltoid will be exerted on the upper fragment, in which it will be aided by the supraspinatus, these muscles overcoming the effort of the latissimus, great teres and great pectoral to pull the lower end of this fragment inward.

Non-union or **ununited fracture** is said to be found more frequently after fracture of the shaft of the humerus than in the case of any other bone.

The student will have noted the close relation of the muscular tissue to the shaft of the bone, the triceps posteriorly and the brachialis anticus anteriorly being intimately adherent. This relation favors the lodgement of fragments of muscular substance between the surfaces of the fractured ends of the bone and interferes with union. While this is recognized as the chief factor in preventing union, another is considered to be the difficulty of retaining the lower fragment in contact with the upper, owing to the tendency it manifests to follow any motion of the forearm at the elbow-joint.

The **nutrient foramen** should be noted near the middle of the shaft, on the inner surface of the bone, its direction being downward. The direction of the nutrient artery as it enters the shaft of a long bone is related to the time of union of the shaft with the epiphyses, that epiphysis toward which the artery is directed uniting first. Thus, as noted above, the upper epiphysis of the humerus unites with the shaft in the nineteenth year, whereas the lower joins the shaft from the fourteenth to the eighteenth year. For the same reason that normal growth is less active in that end of the bone toward which the nutrient foramen does not point, *morbid processes* are more prone to occur here; hence, the upper part of the humerus is more liable to *sarcoma* than the lower part.

The **lower extremity** of the humerus presents in front the coronoid fossa and a shallower excavation to accommodate the head of the radius during flexion; behind, is seen the olecranon fossa. The thinness of the bony tissue intervening between the olecranon and the coronoid fossæ is particularly obvious when this end of the bone is held up to the light; in fact, this thin shell of bone is sometimes perforated (the supra-trochlear foramen). The weakening of the bone in this way explains its liability to *fracture* at this point, this liability being augmented by the relation of the olecranon, since the latter process may be driven forcibly against the thin plate of bone with disastrous consequences. If the resulting fracture is a transverse one, it is known as *supracondylar;* if, in addition, a longitudinal line of fracture extends from the transverse line to the articular surface between the condyles, it is designated an *intercondylar* or *T-fracture*, the important distinction between the two being that the latter involves the joint, while the former does not necessarily do so.

The **condyles** are seen to differ in size. A fracture of either which involves the articular surface is called a fracture of the condyle, while a fracture not so implicating the joint is distinguished as a fracture of the inner or outer epicondyle.

The **lower epiphysis** of the humerus presents what might be called certain irregularities. Thus, the ossific centre for the capitellum and outer part of the trochlea (sixth month), that for the remainder of the

trochlea (tenth year) and possibly that for the tip of the outer condyle (fourteenth year) fuse with the diaphysis from the fourteenth to the fifteenth year or as late as the seventeenth (Poland), while the centre for the inner condyle, which appears at the fifth year, remains separate from the epiphysis proper and does not acquire bony union with the shaft until the eighteenth year. Hence, epiphyseal separation or so-called epiphyseal fracture may occur in which the inner condyle may not participate. For this reason also, the epiphyseal line is said to extend frôm a point just below the inner condyle to a point just above the outer condyle.

From these considerations it will be evident that interference with the epiphyseal line of growth, as by excision of the elbow-joint, will check the growth of the shaft in length from its lower epiphysis if such interference occur prior to the fifteenth year, although growth in length could still take place from the upper epiphysis since it does not unite with the shaft until the nineteenth year.

THE REGION OF THE ELBOW.

Before undertaking the dissection of the elbow region and the forearm the student will do well to review the bones of the forearm. For this purpose let him procure specimens and study them in connection with the text and the drawings.

The Ulna.—The **shaft** with its rounded *anterior* and *posterior borders* and its sharp *external* or *interosseous border* should be noted, as also the marking off by these borders of the *posterior*, *internal* and *anterior surfaces* and their respective areas for muscular attachments (Figs. 48 and 49). The large **upper extremity** of the bone, presenting the *olecranon* and *coronoid processes* and the *greater* and *lesser sigmoid cavities* and the various impressions and prominences for the attachment of muscles, must also receive attention. The small **lower extremity,** with its small rounded *head*, its *styloid process* and its *articular surfaces*, are equally worthy of note.

The Radius (Figs. 50 and 51).—Note that the **shaft** presents a sharp *internal* or *interosseous border* and more rounded *anterior* and *posterior* borders and an *oblique ridge* looking forward, which is the upper part of the anterior border, as well as the *bicipital tuberosity*. Note also the various muscular areas. The small **upper extremity** consists of the flattened *head* which is wholly articular and the *neck*. The large **lower extremity** with its dorsal *ridges* and intervening *grooves* for the play of tendons, its prominent *styloid process* on the outer aspect, its *sigmoid cavity* on the inner side for articulation with the head of the ulna, and its inferior *articular surface* for the scaphoid and semilunar bones should be given careful attention.

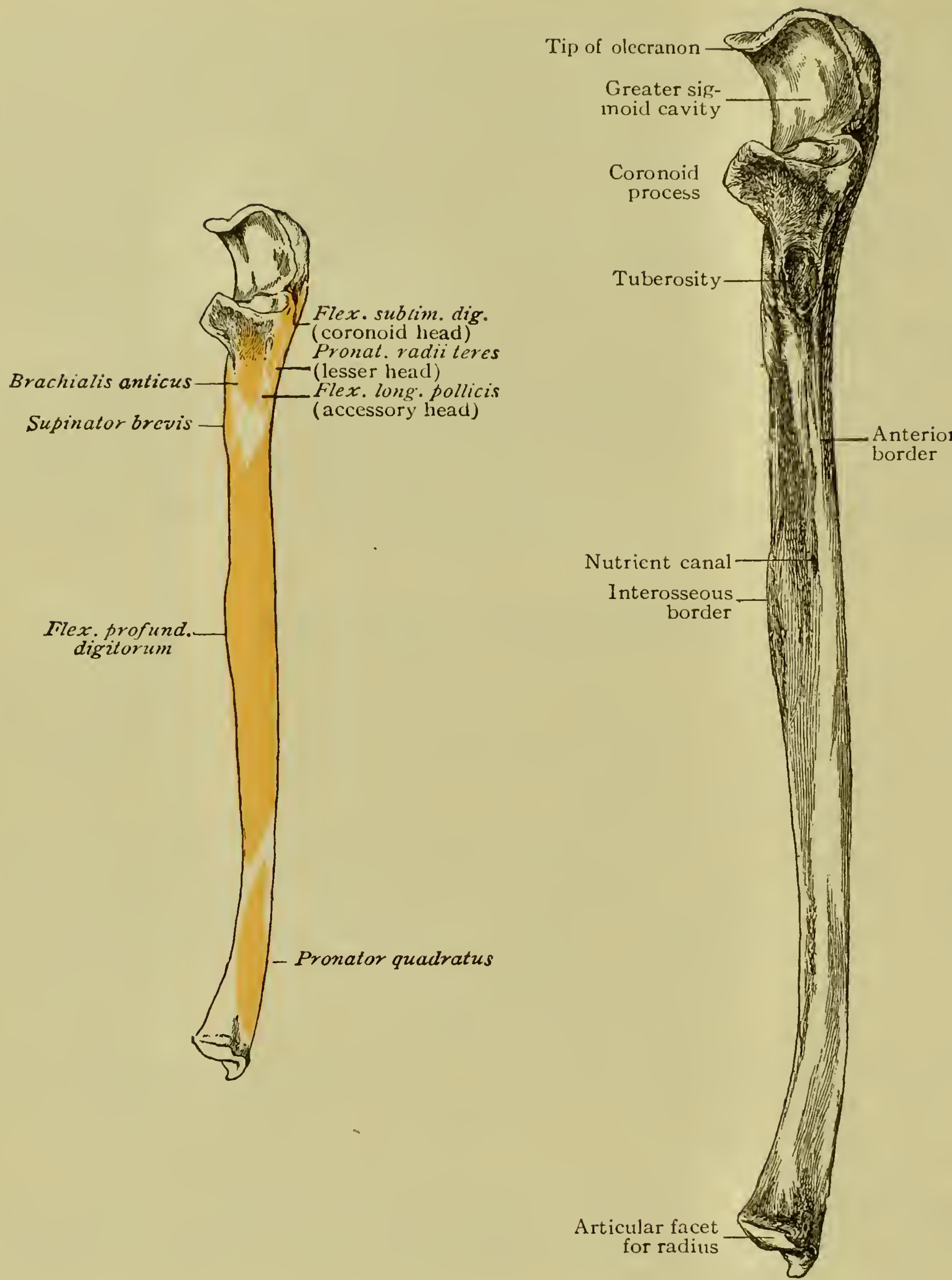

FIG. 48.—Right ulna, inner aspect. The outline figure shows the areas of muscular attachment.

THE SURFACE ANATOMY.

The **inner** and **outer condyles** of the humerus appear respectively on the inner and outer sides of the elbow-joint as conspicuous bony prominences. A line connecting the condyles forms a right angle with

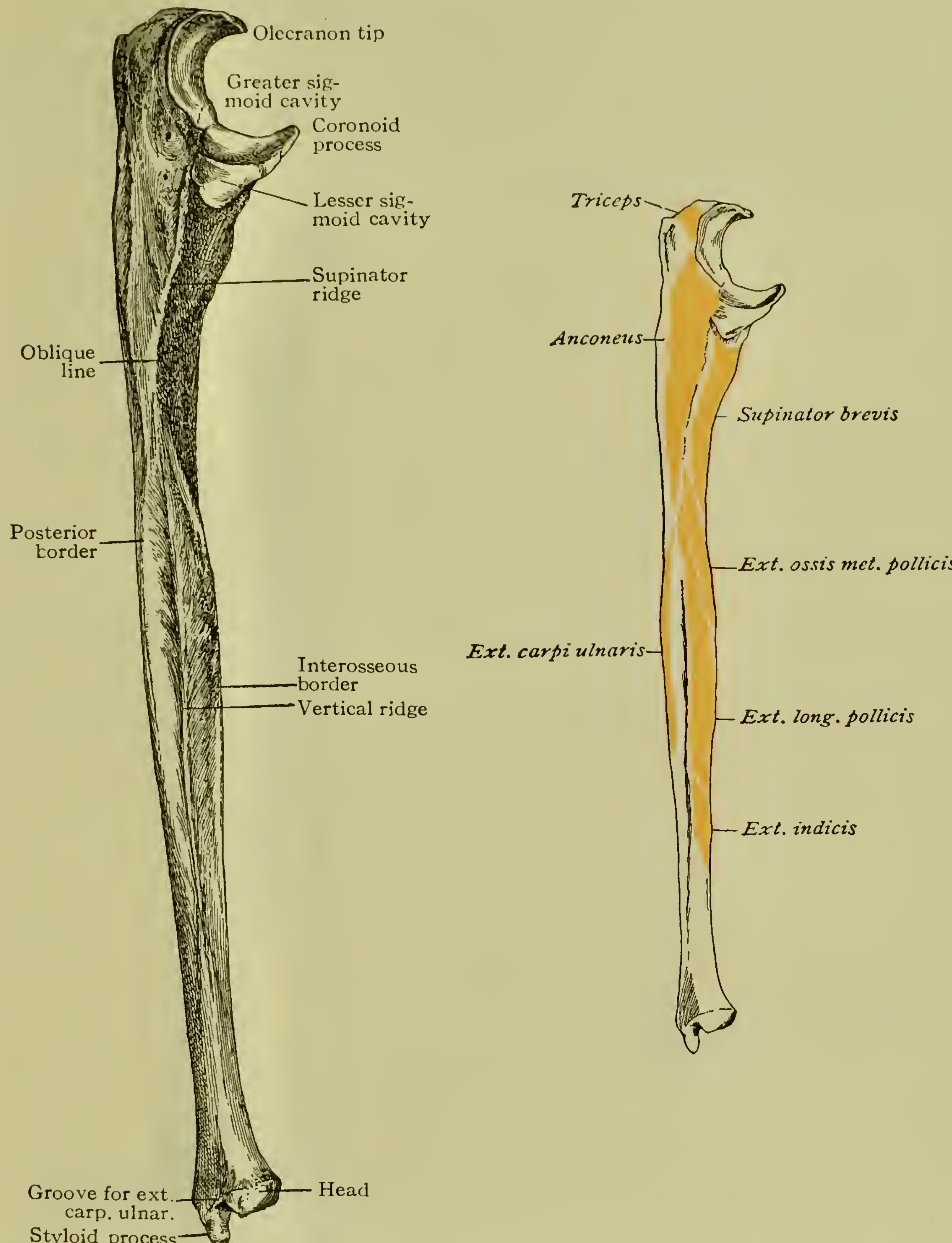

FIG. 49.—Right ulna, outer aspect. The outline figure shows the areas of muscular attachment.

the shaft of the humerus. The respective **supracondylar ridges** are easily felt above the condyles. The *inner condyle*, much the more prominent, gives attachment to the superficial flexor group of muscles of the forearm, these muscles forming the longitudinal eminence below the condyle. Behind the inner condyle and between it and the olec-

ranon process of the ulna, the palpating finger sinks into a depression, the interval between the two bony processes mentioned, which contains the ulnar nerve and the posterior ulnar recurrent artery. Hence a sharp blow upon the inner condyle produces tingling in the fingers if

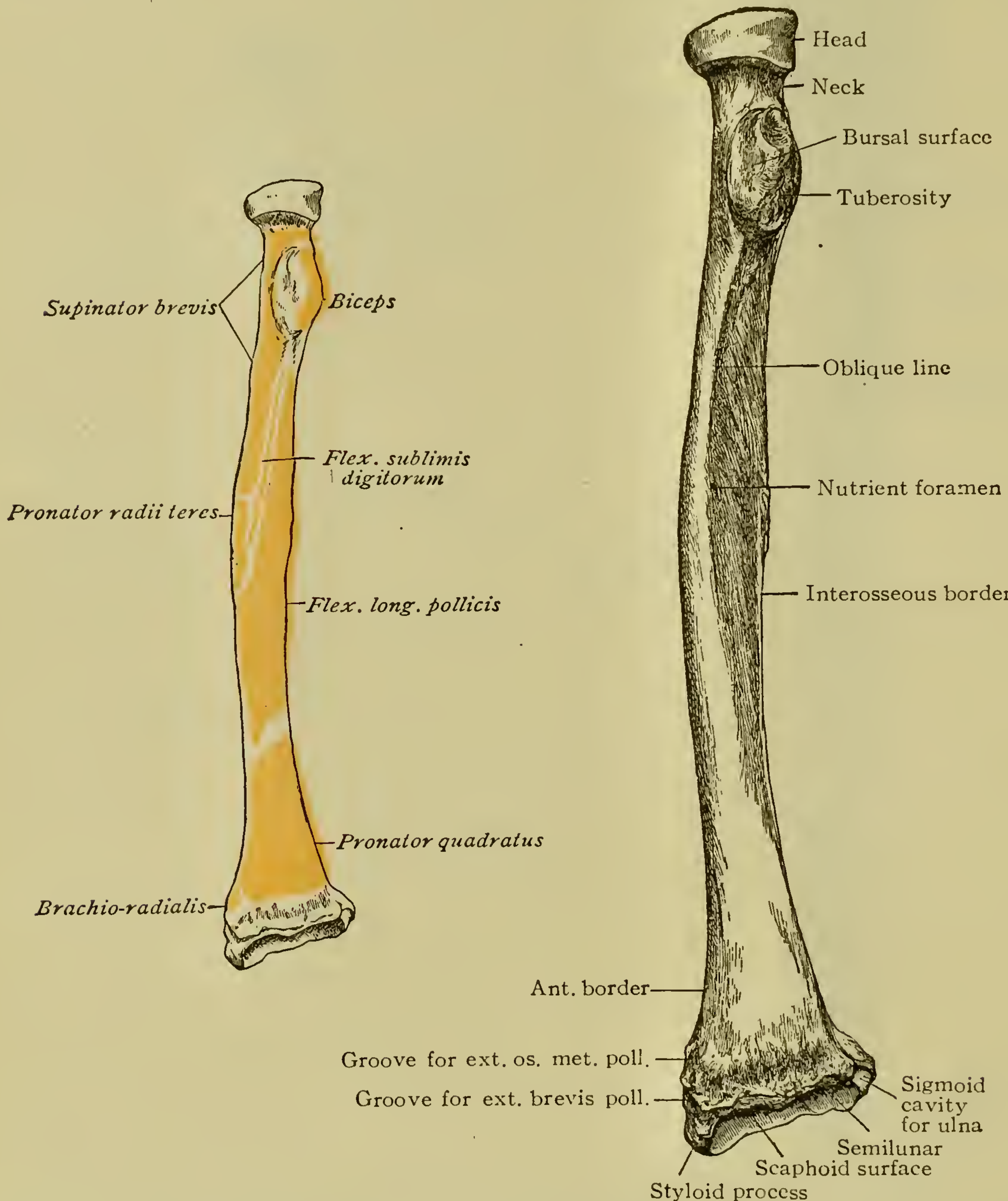

Fig. 50.—Right radius from before. The outline figure shows the areas of muscular attachment.

the nerve be at all implicated. The *outer condyle* and the external condylar ridge give attachment to some of the extensor muscles of the forearm and the brachio-radialis, these muscles occasioning the large fleshy mass in front of this condyle.

The **olecranon process of the ulna,** the "tip of the elbow," the very conspicuous projection on the posterior aspect of the joint (Fig. 45), occupies the same horizontal plane as the condyles when the forearm is extended, and the same vertical plane when the forearm is flexed to form an angle of 90 degrees with the shaft of the humerus with the latter bone in the vertical position.

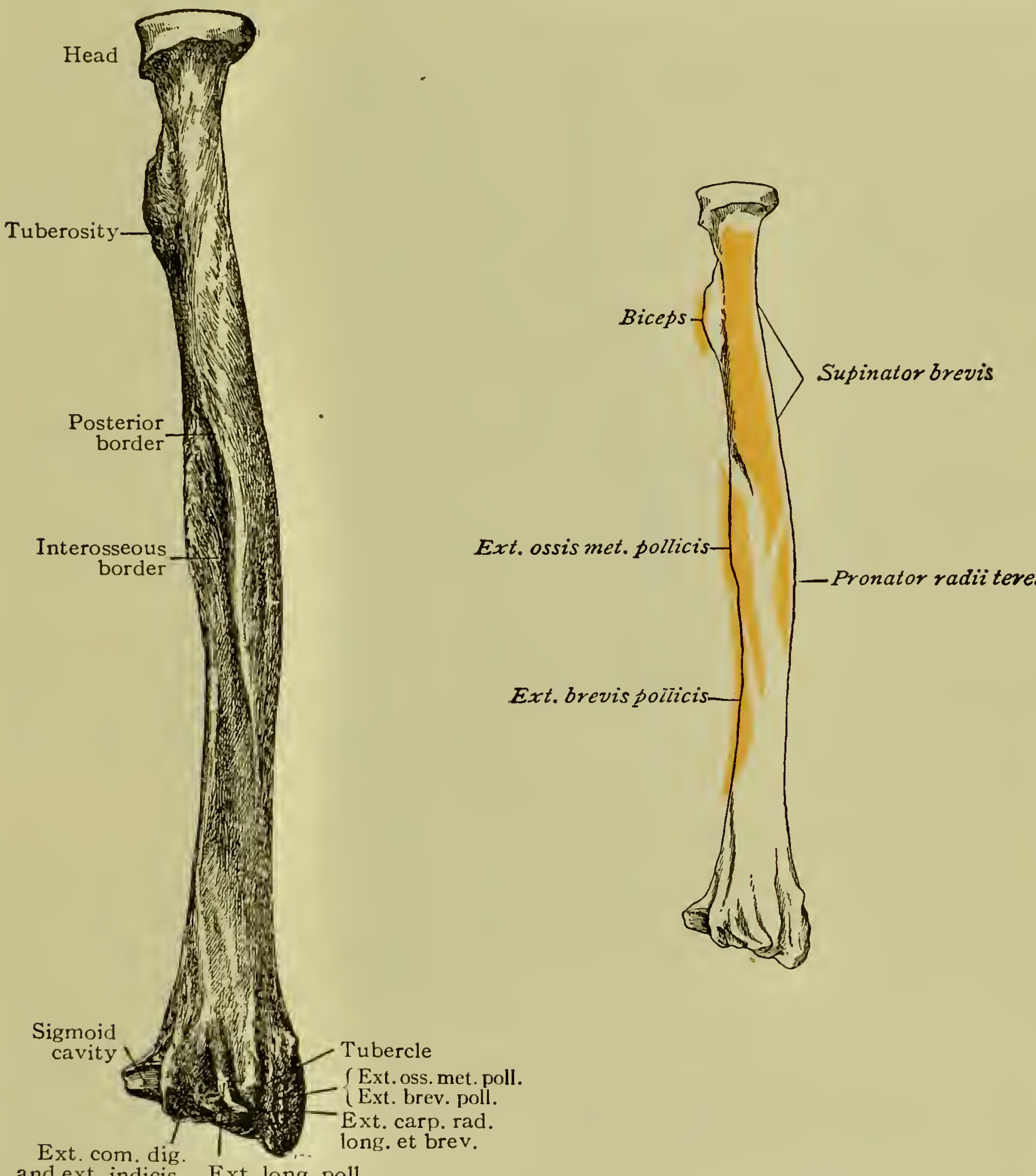

FIG. 51.—Right radius from behind. The outline figure shows the areas of muscular attachment.

The relation of the olecranon to the condyles is of importance in differentiating a *supracondylar fracture of the humerus* from *dislocation of the elbow-joint*, the olecranon being displaced from this relation in any dislocation of the ulna, while in a supracondylar fracture the relation is not disturbed.

The position of the **head of the radius** (Fig. 10) in a fleshy subject is indicated by a depression or dimple just below the external condyle. Placing the finger upon this dimple and alternately pronating and supinating the forearm, the head of the radius may be felt to rotate beneath the finger. In a muscular individual with little fat, the head of the radius forms a surface prominence which is differentiated from the external condyle by a depression.

The **antecubital fossa** is the depression upon the anterior surface of the bend of the elbow (Fig. 39). This fossa is limited above by an imaginary line drawn from one condyle to the other, while it is bounded on the inner side by a ridge due to the pronator radii teres extending obliquely from the inner condyle to the outer side of the forearm, and upon the outer side by the muscular prominence occasioned chiefly by the brachio-radialis.

The *superficial veins* of this region are usually easily recognizable in the living subject except in the case of the obese. They are referred to more fully on page 97.

The *tendon of the biceps* may be plainly felt in the living subject, passing into the middle of this space when the forearm is voluntarily flexed, and the *bicipital tuberosity of the radius* may be obscurely felt at the termination of the tendon when the forearm is slightly rotated in the supine position. The *bicipital fascia* (semilunar fascia) may be recognized as a tense band passing from the inner side of the tendon toward the inner side of the upper part of the forearm (Fig. 52), and its inner edge may be outlined by pressure with the index-finger beneath the inner edge of the band. If the pressure of the finger be sufficiently deep, the pulsations of the *brachial artery* may be felt.

DISSECTION OF THE ANTECUBITAL SPACE.

With the forearm in the supine position, a median incision should be made from the bend of the elbow to the wrist. Beginning at the upper end of this incision, the skin should be carefully dissected toward either side of the forearm, but the dissection should not be carried farther down than the middle of the forearm until the structures of the antecubital space shall have been dissected. In reflecting the skin-flaps, great care should be exercised not to cut too deeply, since the skin is thin and there are superficial structures of importance to be preserved. Having reflected these flaps to a sufficient extent to expose fully the antecubital space, the superficial fascia of the region and its contents may be inspected.

The Superficial Fascia.—The student will note the presence of several rather large **veins** and these should be more fully exposed by carefully removing the connective tissue and fat from their surfaces, keeping a close lookout while doing so for small nerve-trunks. The

typical arrangement of these veins is for the **median vein** (see p. 102), coming up the middle of the forearm, to bifurcate into an outer trunk, the **median cephalic,** and an inner trunk, the **median basilic,** which, diverging from each other, unite, the median cephalic with the **radial vein** in the outer part of the space to form the **cephalic vein,** and the median basilic with the **common ulnar** to form the **basilic vein** (Fig. 52).

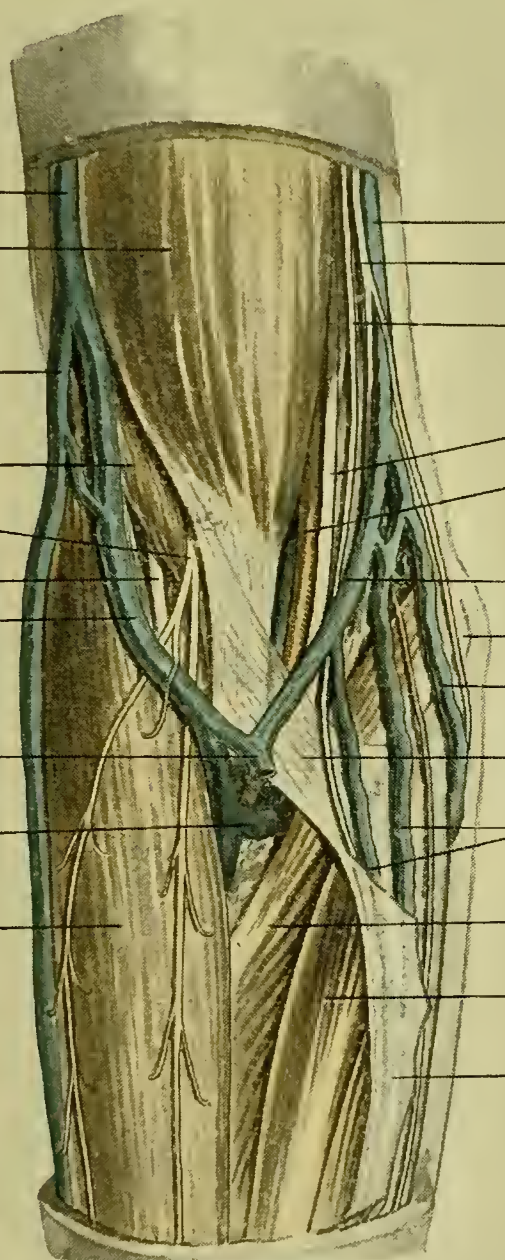

FIG. 52.—Dissection of the anterior surface of the elbow-region.

In dissecting the median basilic vein, which is the largest of the group, the dissector should look for the **anterior division of the internal cutaneous nerve,** which may cross this vein superficially or pass beneath it, as well as for one or more branches of this nerve. In isolating the median cephalic vein, the **cutaneous division of the musculo-cutaneous nerve** will be encountered passing downward and outward through the outer part of this space but at a somewhat deeper plane than the vein (Fig. 52).

The veins at the bend of the elbow, by reason of their large size and superficial situation, are usually selected as the vessels most suitable for *venesection,* one form

of *blood-letting.* The median basilic is chosen in preference to the median cephalic because of its larger calibre, which renders it more easily discoverable. Since it is separated from the brachial artery only by the bicipital fascia, some degree of caution is necessary in performing the operation to avoid injuring the artery, such injury sometimes resulting in *arterio-venous aneurism.*

Having divested the veins of connective tissue, the nerves mentioned above should be picked up with forceps and followed to the limits of the space. In the extreme inner part of the space will usually be found an additional branch of the anterior division of the internal cutaneous nerve. In dissecting these nerves, each recognizable trunk or filament may be raised slightly with the forceps so as to make it taut, when a few strokes of the scalpel parallel with the nerve will free it of connective tissue. Having completed the dissection of the veins and nerves of the region, the remnants of the superficial fascia may be cleared away to expose the deep fascia. In doing this, regard should be had for the **bicipital fascia** coming off as a somewhat fan-shaped expansion from the inner side of the tendon of the biceps to blend with the deep fascia of the forearm (Fig. 52).

It will be apparent that the connection of the bicipital tendon with the deep fascia of the forearm tends to cause some of the force of that muscle to be expended upon the muscular mass on the inner side of the forearm and, since most of these muscles have at least some part of their origin from the deep fascia of the forearm, the force of the biceps is therefore distributed toward the distal extremity of the forearm, thus enabling the muscle to act to better advantage as a flexor than if all its force were exerted upon its point of insertion, the tuberosity of the radius.

The Deep Fascia.—The deep fascia thus exposed is sufficiently translucent to reveal in a measure the underlying muscles. It will be noted that it presents lines of opaqueness which indicate intervals between neighboring muscles, into which intervals are prolonged septa of the deep fascia which serve to separate the muscles from each other and to afford partial origin to them.

A median incision should now be made through the deep fascia and it should be reflected toward either side. This dissection should be done by raising a corner of the flap sufficiently to make gentle traction and by cautiously making a few light cuts with the knife parallel to the deep surface of the flaps in order to avoid injury to underlying structures. At the inner side of the antecubital space the pronator radii teres will be exposed, while upon the outer side will be seen the brachio-radialis (or supinator longus) muscle (Fig. 52).

Deep Contents of the Antecubital Space.—The terminal part of the **brachial artery** should now be isolated, the previously dissected portion of the vessel in the upper arm serving as a guide to its position; the two terminal branches of the artery—the **radial** and the **ulnar**—should also be exposed so far as they belong to this space. The **radial recurrent artery,** arising from the beginning of the radial, should be

located and followed outward and upward to the region of the outer condyle, in front of which it anastomoses with the superficial branch of the superior profunda. The **anterior ulnar recurrent branch** of the ulnar artery, arising near the origin of that vessel, should be identified and traced upward and inward beneath the pronator radii teres to the front of the inner condyle of the humerus where it inosculates with the anastomotica magna and the inferior profunda. The **posterior ulnar recurrent,** larger than the anterior ulnar recurrent but smaller than the radial recurrent, arises from the ulnar artery under the upper part of the superficial flexor muscles and gains the interval between the inner condyle and the olecranon through which interval it passes to anastomose with the inferior profunda and anastomotica magna. The **common interosseous branch** of the ulnar artery, a short, thick trunk arising from the ulnar near its origin, will be found very deeply placed in the space, it being necessary to elevate the ulnar artery somewhat and to displace neighboring muscles in order to bring it to view. The common interosseous bifurcates into the *anterior interosseous*, which passes down the forearm on the anterior surface of the interosseous membrane, and the *posterior interosseous*, which goes to the back of the forearm through the interosseous space above the membrane. The **accompanying veins** of the foregoing vessels will be encountered in the steps thus outlined, and it will be noted that these veins are smaller than the superficial veins mentioned above, and that they communicate here with the superficial veins by several trunks.

The greater size of the superficial veins as compared with the deep veins offers an explanation of the fact that even slight constriction of the forearm or arm, as by a badly applied bandage, may suffice to obstruct seriously the venous return and so cause *œdema* or local dropsy of the part.

The **median nerve,** lying upon the inner side of the brachial artery, is an important constituent of this space. It should be cleaned carefully so as to avoid injuring any of its branches; traced to the lower and inner limit of the space, it will be seen to pass between the two heads of the pronator radii teres. Its largest branch in this region is the *anterior interosseous nerve*, which pursues a course almost corresponding to the median line of the forearm and sinks deeply into the space to gain a position upon the anterior surface of the interosseous membrane where it lies in close relation with the anterior interosseous artery. Other *branches*, variable in number and position, are given to the superficial flexors on the inner side of the space (Fig. 56). Its branches in the forearm will be more fully given below.

The **posterior interosseous nerve** should be looked for in the extreme outer part of the space under the edge of the brachio-radialis muscle. Its recognition may be facilitated by tracing it from its origin, the bifurcation of the musculo-spiral nerve, in the interval between the

brachio-radialis and the brachialis anticus. Traced downward it will be found to lie upon the supinator brevis muscle and then to enter this muscle, between the superficial and deep parts of which it passes to reach the dorsal aspect of the forearm, passing in its course backward upon the outer side of the radius (Fig. 69).

The **radial nerve,** the other terminal branch of the musculo-spiral, may be similarly traced downward from its origin, it being necessary in order to expose it to displace the brachio-radialis outward, since it is overlapped by that muscle.

The **tendon of the biceps** passing into the middle of the space at its upper boundary upon the outer side of the brachial artery sinks deeply to reach its insertion upon the back part of the bicipital tuberosity of the radius. Between the terminal portion of the tendon and the forepart of the bicipital tuberosity is a bursa (Fig. 72) which may be recognized by the presence of the small amount of slippery fluid which escapes when it is incised.

Referring to the articulated radius and ulna, the student will note that the bicipital tuberosity looks inward and somewhat backward when the forearm is in the supine position, while it is made to look backward and outward when the forearm is pronated, hence the object of the bursa in preventing friction and undue pressure during pronation will be apparent. It will also be evident that *inflammation of this bursa* will be attended with pain upon movement of the forearm, and some consequent disability, and hence might be mistaken for inflammation of the elbow-joint. From the position the bicipital tuberosity assumes in pronation, as above noted, it will be evident that the biceps is not only a flexor of the forearm, but also an important supinator.

The **floor** of the antecubital fossa is constituted by the brachialis anticus muscle and by the supinator brevis. The surfaces of these muscles should now be cleaned that they may be traced to their points of insertion.

The insertion of the brachialis anticus into the coronoid process of the ulna renders it a flexor of the forearm, and by reason of this insertion it is stated that a *fractured coronoid process* is displaced upward by this muscle; since, however, the insertion of the muscle is prolonged to the shaft of the ulna, this displacement is questionable. The important relation of this muscle to the elbow-joint should be noted; it will be evident that an effusion into the elbow-joint could scarcely be very obvious in front on account of the relation of this muscle, such an effusion being more apparent on the posterior and lateral aspects of the joint.

THE ANTERIOR SURFACE OF THE FOREARM.

SURFACE ANATOMY.

In a subject with good muscular development the width of the forearm near the elbow, owing to the mass of the flexors on the ulnar side and the brachio-radialis and the radial extensors of the wrist on the radial side, is almost double its width near the wrist, where the muscular bellies have been replaced by the corresponding tendons. The distinc-

tion between the two groups of muscles may be brought out in the living subject by active flexion of the wrist, the fingers being extended, and by alternately tightening and relaxing the clenched fist; the brachioradialis may be made especially evident by strongly flexing the forearm with the thumb pointing upward, that is, midway between pronation and supination.

The **radius** and **ulna** are masked to a considerable degree by the muscles, especially above. The *radius* may be palpated along the outer border of the upper two thirds of the forearm by deep pressure; in the lower third it becomes almost subcutaneous, the lower extremity of the bone being easily felt beneath the upper transverse crease at the front of the wrist, as is also its *styloid process*, at the outer side of its base, terminating at the level of the lower transverse crease. The *lower end of the ulna* is to be felt plainly, especially when the wrist is gently flexed, that is, without bringing the ulnar carpal flexor into pronounced action, while the *styloid process* of the ulna, reaching a lower level, is recognized at the posterior aspect of the wrist during full supination, but seems to approach the flexor surface in pronation.

The most conspicuous tendon on the palmar aspect is one about the middle of the lower end of the forearm or of the wrist, the **tendon of the palmaris longus** (Fig. 39), not infrequently absent, to the radial side of which is a much larger tendon, that of the **flexor carpi radialis.** Between these two tendons lies the **median nerve.** On the radial side of the flexor carpi radialis tendon and between it and the tendon of the brachioradialis will be felt the **pulsations of the radial artery.** On the ulnar side of the palmaris longus tendon will be found the tendons of the **flexor sublimis digitorum,** best recognized when the fingers are forcibly flexed; and still nearer the ulnar side of the forearm is the tendon of the **flexor carpi ulnaris** leading to the **pisiform bone** which forms the first bony prominence encountered on the palmar aspect of the wrist on the ulnar side below the end of the ulna. The **pulsations of the ulnar artery** may be felt between the tendon of the flexor carpi ulnaris and that of the palmaris longus, and between the artery and the flexor carpi ulnaris tendon lies the **ulnar nerve.** Of the several **transverse furrows** across the front of the wrist, the more conspicuous is the distal one which marks the upper limit of the anterior annular ligament, crosses the neck of the os magnum, and lies three quarters of an inch below the highest point of the wrist-joint.

DISSECTION.

The median incision previously made is to be prolonged to the upper border of the palm of the hand, at which point a transverse incision must be added. These incisions should include only the skin. The skin-flaps thus outlined are to be detached as far as the inner and

outer borders of the forearm with due precaution against injuring the cutaneous vessels and nerves. The skin having been reflected, the superficial fascia and its contents should be dissected.

The Superficial Fascia.—This fascia, containing a variable amount of fat, presents the ramifications of the **superficial blood=vessels,** notably the superficial veins, and the **superficial nerves.**

The **median vein** (Fig. 53), not infrequently consisting of several trunks, should be first dissected, being followed from the antecubital space, where it bifurcates into the *median basilic* and the *median cephalic veins* (p. 97), toward the wrist, where it *originates* by the confluence of several small tributaries. In dissecting this vein, as in dissecting the others, the fascia should be cleared from its superficial surface first, after which the vein should be raised at one point and gradually freed from connective tissue. A few cutaneous nerve filaments will be encountered in following this vein downward and the **palmar cutaneous branch** of the median nerve should be looked for in close proximity to the vein a few inches above the wrist (Fig. 53), at which point the nerve pierces the deep fascia to become an occupant of the superficial fascia; it is rather more deeply placed in the superficial fascia than the vein.

The **superficial radial vein,** or the antebrachial portion of the cephalic vein on the radial side of the forearm and partly on its dorsal surface, should be dissected in similar manner, a watch being maintained for the cutaneous filaments which intersect its course, such as those of the **anterior branch of the musculo=cutaneous nerve.** The **origin** of this vein is the venous network of the first intermetacarpal space (Fig. 67). It *terminates* near the elbow by uniting with the median cephalic to form the cephalic vein.

The **anterior** or **superficial ulnar vein,** the antebrachial portion of the basilic vein, on the ulnar side of the forearm, should be dissected from above downward to its *origin* in the ulnar side of the dorsal venous network of the hand (Fig. 67). It *terminates* (p. 97) by uniting with the posterior ulnar to form the common ulnar vein (Fig. 53), or by joining the median basilic. A few inches above the wrist the **palmar cutaneous branch of the ulnar nerve** (Fig. 53) may be encountered in the vicinity of this vein.

The **anterior division of the internal cutaneous nerve** (Fig. 53), crossing or passing under the median basilic vein, pursues a course along the ulnar side of the forearm, giving off branches to the skin as it goes. This nerve and its branches should be successively isolated and followed.

The **anterior trunk of the cutaneous division of the musculo=cutaneous nerve** (Fig. 53) is found on the radial side of the forearm distributing branches to the integument and passing downward to the wrist to terminate in cutaneous filaments.

The **palmar cutaneous branch** of the median nerve, and the **palmar cutaneous branch** of the ulnar nerve have been mentioned above, and if they have been isolated as far as their entrance into the palm, nothing more is to be done with them at present.

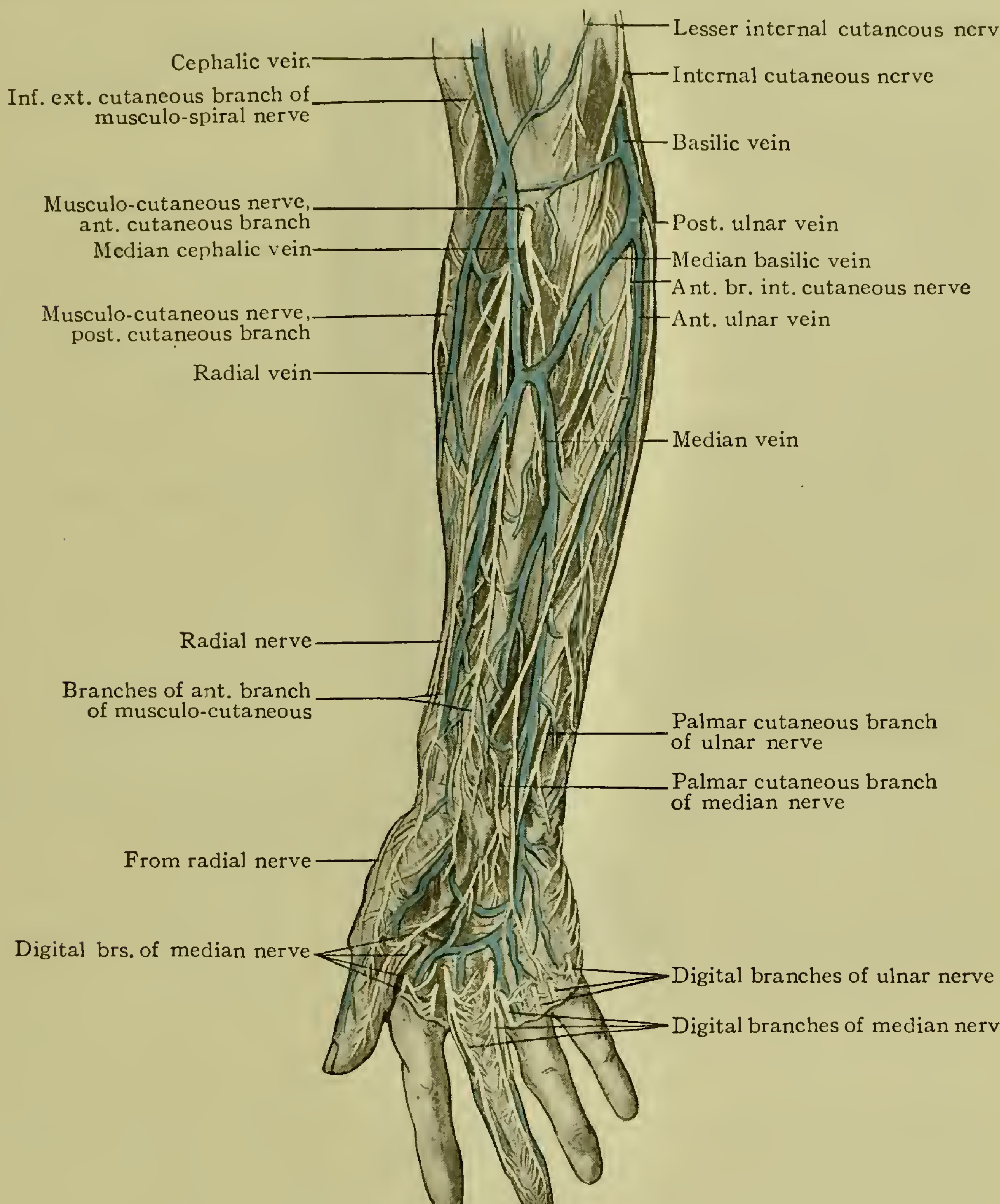

FIG. 53.—Cutaneous nerves and vessels of the anterior surface of the forearm and hand.

The **radial nerve,** although not an occupant of the superficial fascia, must be taken note of here in order that it may not be overlooked and so injured. This nerve, one of the terminal branches of the musculo-spiral (p. 86), passes down the outer side of the forearm on the radial side of the radial artery under the inner border of the brachio-radialis muscle

to the junction of the middle third with the lower third of the forearm, where it lies beside the tendon of this muscle and then winds around to the dorsal aspect of the forearm to pursue its further course to the dorsal

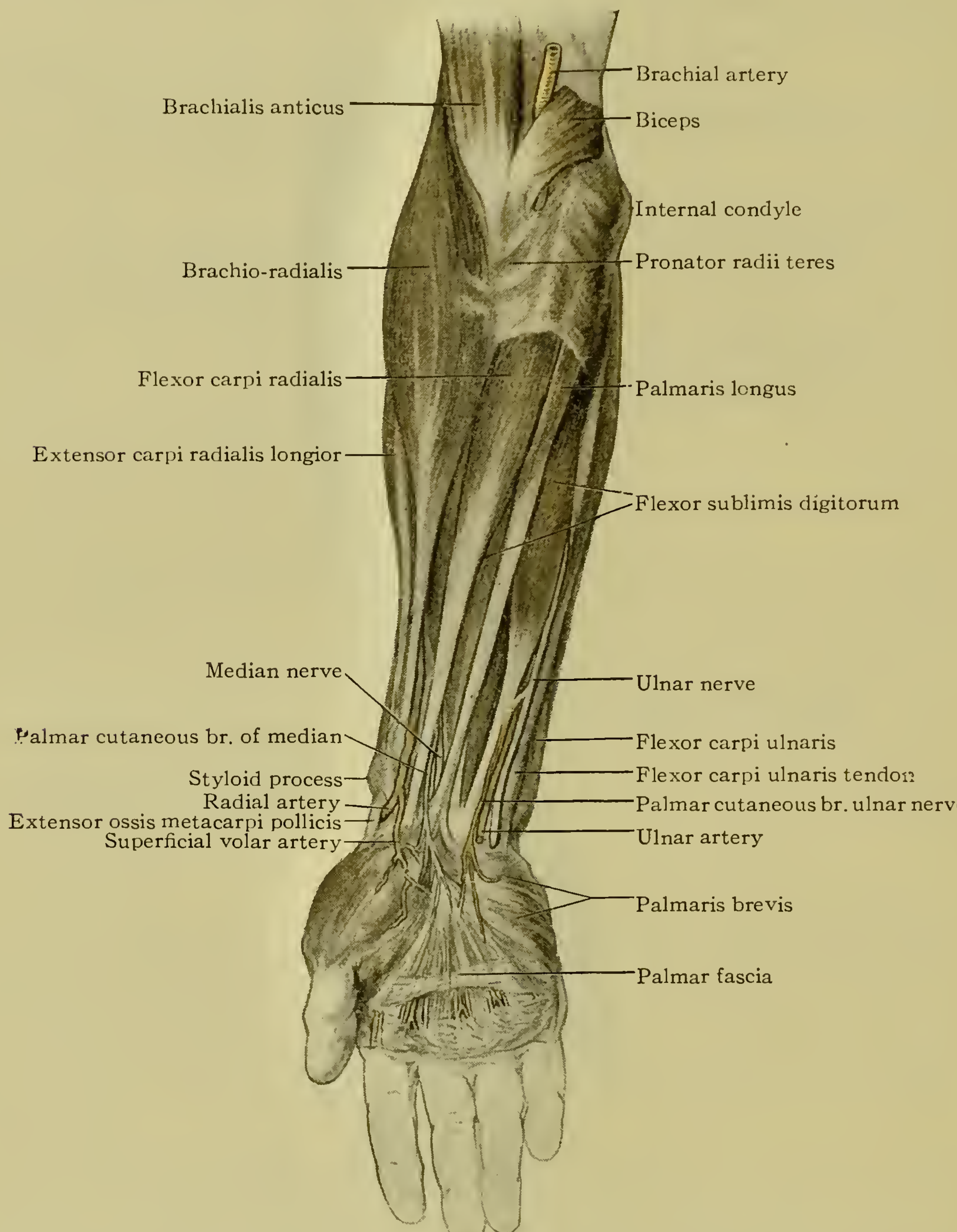

FIG. 54.—Dissection of the anterior surface of the forearm and hand, showing the muscles in undisturbed relation.

surface of the hand. In passing from the anterior to the dorsal surface of the forearm, although not superficial to the deep fascia, it may be injured by a careless dissector in denuding the surface of the latter.

This method of dissecting the superficial fascia and its contents interferes with the removal of this fascia in the form of distinct flaps, a disadvantage, however, which is more than offset by the advantage of preserving intact the nerves and vessels. These latter having been dissected and studied, the remaining fragmentary parts of the superficial fascia should be removed from the surface of the deep fascia, the tissues being moistened if necessary to facilitate the work.

The Deep Fascia (antebrachial fascia). — This structure forms a closely fitting investment for the muscles and deeper structures and helps to give origin to some of the muscles both by its deep surface and by the numerous septa or processes which it sends inward between muscles and groups of muscles. Being translucent, the muscles may be to a certain extent recognized through the fascia, notably the mass constituted by the superficial group of flexors on the ulnar side of the forearm, and the radial group on the radial side. On the lower part of the forearm the tendons of these muscles may be recognized. Continuous above with the deep fascia of the arm (brachial fascia) where it is reinforced by the semilunar fascia of the biceps, it becomes stronger below and acquires attachments to the bones of the forearm and wrist. Above the wrist the fascia presents a localized thickening, the **ligamentum carpi volare,** which serves to bind down the tendons. Farther down, it is continuous with a much stronger band, the **anterior annular ligament** (ligamentum carpi transversum) (Fig. 60), which stretches across the front of the wrist. A transverse incision across the wrist and a longitudinal median incision may now be made and the two flaps of the deep fascia may be reflected without disturbance of underlying parts. This will afford the dissector an opportunity to study the structures in their undisturbed relations (Fig. 54).

On the ulnar side of the forearm, in the lower third, is the ulnar artery, lying upon the outer or radial side of the tendon of the flexor carpi ulnaris muscle. On the ulnar side of the artery is the ulnar nerve. On the radial side of the forearm in the lower third or half will be seen the radial artery lying upon the inner or ulnar side of the tendon of the brachio-radialis as far down as the lower extremity of the forearm when the artery passes outward under the tendons of the metacarpal extensor and short extensor of the thumb to reach the dorsal aspect of the wrist. The most superficial tendon near the median aspect of the forearm is that of the palmaris longus muscle and upon the radial side of this is the much larger tendon of the flexor carpi radialis. Between these two tendons and on a somewhat deeper plane, will be found the median nerve lying partly under the two tendons last mentioned; while upon their inner or ulnar side will be seen a group of tendons, four in number, which belong to the flexor sublimis digitorum. The radial nerve mentioned above is also conspicuously seen in the middle third of the fore-

arm on the radial side. At the front of the wrist is the conspicuous transverse band mentioned above, the anterior annular ligament, under which pass the median nerve and the tendons of the flexor longus pollicis and of the flexor sublimis and flexor profundus digitorum, while the ulnar artery and the ulnar nerve pass over this ligament to reach the palm. Each one of the structures mentioned should be cleaned without disturbing the relations of any of the parts, after which the dissector is ready to proceed with the complete dissection of the individual structures.

The Flexor Carpi Ulnaris (Fig. 56).—**Origin,** from the inner condyle of the humerus in common with the other superficial flexors, from the inner side of the olecranon, from the posterior border of the ulna by the aponeurosis common to this muscle and to the flexor profundus digitorum and extensor carpi ulnaris and from the deep fascia and its septa; **insertion,** the pisiform bone and, secondarily, the unciform process of the unciform and the fifth metacarpal; **nerve=supply,** the ulnar nerve from the eighth cervical and first thoracic; **action,** to flex the wrist.

In denuding the surface of this muscle it will be seen to be aponeurotic above, and to take part of its origin from a septum between it and adjacent muscles. Following this septum it may be separated from the neighboring flexor sublimis almost, but not quite, up to the inner condyle. Pulling the muscle away from the forearm toward the ulnar side, the aponeurosis by which it is connected with the posterior border of the ulna will be demonstrated and at a later stage this aponeurosis will be seen to give origin likewise to the extensor carpi ulnaris and to the flexor profundus digitorum. In separating that head of the muscle which arises from the olecranon from the humeral head, an interval will be exposed which corresponds to the space between the olecranon and the inner condyle, in which space will be found the ulnar nerve and the posterior ulnar recurrent artery. In displacing the muscle as indicated above, the ulnar nerve will be seen to have passed down from the interval just mentioned, while the ulnar artery has curved inward from the apex of the antecubital space.

The Palmaris Longus (Fig. 54).—**Origin,** the inner condyle of the humerus by the common tendon and from the deep fascia and its septa; **insertion,** the palmar fascia; **nerve=supply,** the median nerve from the sixth cervical; **action,** to tense the palmar fascia and to assist in flexing the wrist.

This muscle has been already dissected, or, if not, its complete dissection should now be effected. It is sometimes absent and occasionally double.

The Flexor Carpi Radialis (Fig. 54).—**Origin,** the inner condyle of the humerus by the common tendon and the deep fascia and its

septa; **insertion,** the second and third metacarpal bones at their bases; **nerve-supply,** the median nerve (from the sixth cervical); **action,** to flex the wrist.

The tendon of this muscle cannot be followed to its insertion at this stage; it passes into the hand without going under the anterior annular ligament, but lies in the groove on the trapezium (Fig. 66).

The Pronator Radii Teres (Fig. 52).—**Origin,** *one head* by the common tendon from the inner condyle and the deep fascia and *one head* from the ulnar side of the coronoid process of the ulna; **insertion,** the outer aspect of the radius near its middle; **nerve-supply,** the median nerve (from the sixth cervical); **action,** to pronate and flex the forearm.

The relation of this muscle to the antecubital fossa has been pointed out (page 96). Isolate the palmaris longus and the flexor carpi radialis from the other muscles of the group and pull them well over to the inner side of the forearm to facilitate the cleaning and isolation of the radial pronator. Raising the superficial portion of the muscle will disclose the median nerve; this being isolated, a deeper and small fasciculus of the muscle will be seen, which is that part arising from the coronoid process. In cleaning the muscle to its insertion, the radial artery and the brachio-radialis must be displaced outwardly.

The Flexor Sublimis Digitorum (Fig. 55).—**Origin,** *the humeral head* from the inner condyle of the humerus by the common tendon, *the ulnar head* from the coronoid process of the ulna, *the radial head*, the oblique line of the radius; **insertion,** by four tendons into the sides of the second phalanges of the digits; **nerve-supply,** the median nerve (seventh and eighth cervical and first thoracic); **action,** to flex the second phalanges and to assist in flexion of the first phalanges and of the hand.

To expose this muscle thoroughly, divide the radial pronator near its insertion and reflect it toward the inner condyle, draw the ulnar and radial carpal flexors inward and, having cleaned the surface of the muscle, elevate it with the fingers, taking care not to injure the ulnar artery or the median nerve. It will be seen that the fleshy belly of the muscle soon divides into two planes of muscular tissue, each of which subdivides into two bellies terminating in tendons. The superficial tendons are for the middle finger and the ring finger; the deep tendons for the index- and the little finger. The tendons will be traced to their terminations in the dissection of the hand, when it will be seen that each tendon divides opposite the metacarpo-phalangeal articulation (Fig. 63), and that between the two slips passes in each case the corresponding tendon of the deep flexor. These two slips then reunite to form a groove which lodges the deep tendon and then again separate to be inserted into the sides of the middle phalanx (Fig. 62). This perforation of the tendons of this muscle by the tendons of the deep flexor gives it the synonym of *flexor perforatus*.

The Brachio-Radialis (the supinator longus) (Fig. 54).—**Origin,** the upper two thirds of the external condylar ridge of the humerus and the external intermuscular septum; **insertion,** the styloid process of the

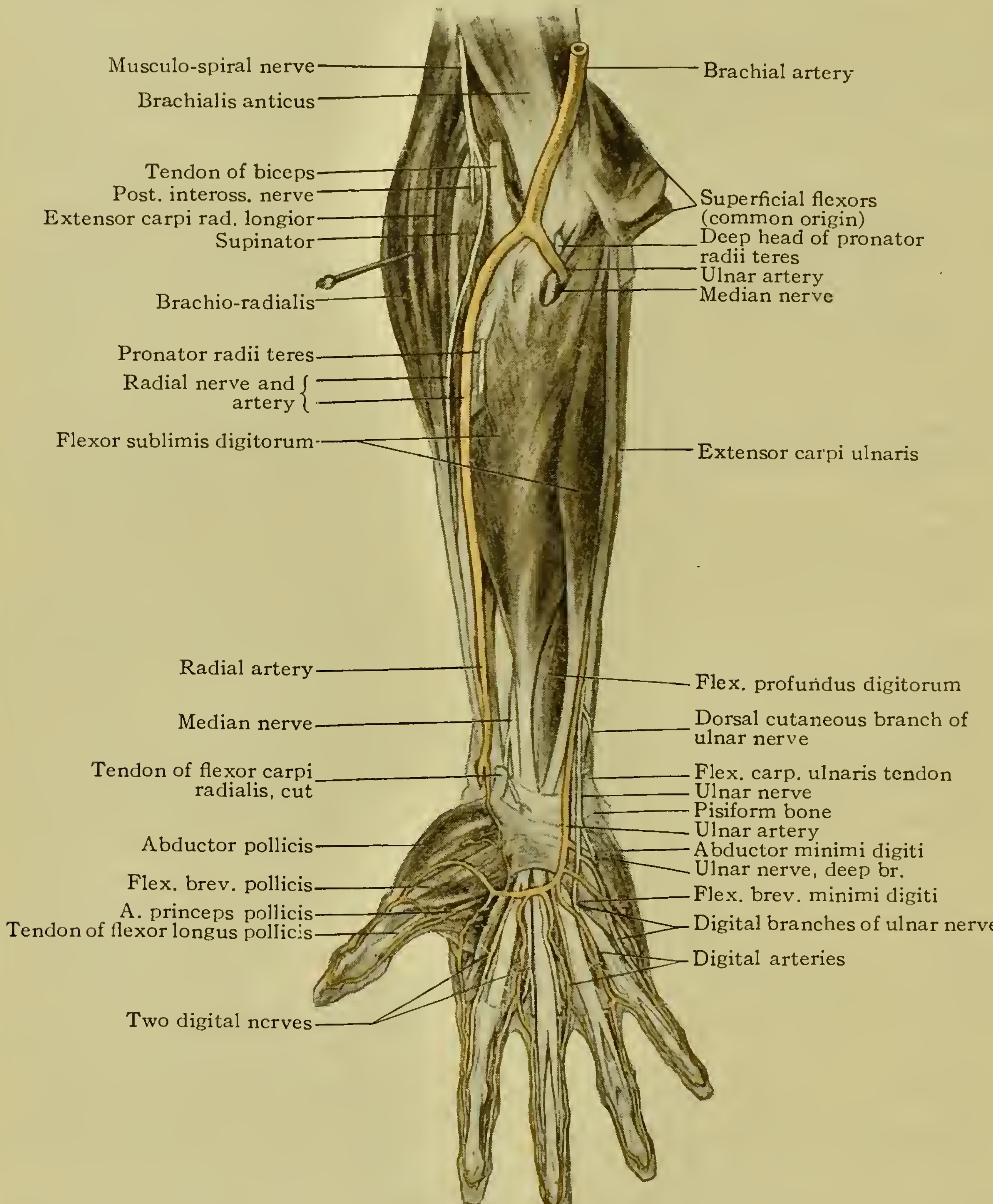

Fig. 55.—Dissection of anterior surface of forearm and hand, showing radial artery, the flexor carpi radialis, the pronator radii teres and the palmaris longus having been removed.

radius; **nerve-supply,** the musculo-spiral nerve (fifth and sixth cervical); **action,** to assist in pronation, supination and flexion of the forearm.

After cleaning the surface of this muscle it should be gently separated from the underlying radial extensors of the wrist, and, near its origin,

from the brachialis anticus, due regard being paid the radial nerve and the radial artery which lie under its inner border. Placing the forearm in the supine position and pulling upon the upper portion of this muscle will demonstrate that it can pronate the forearm only to the extent of

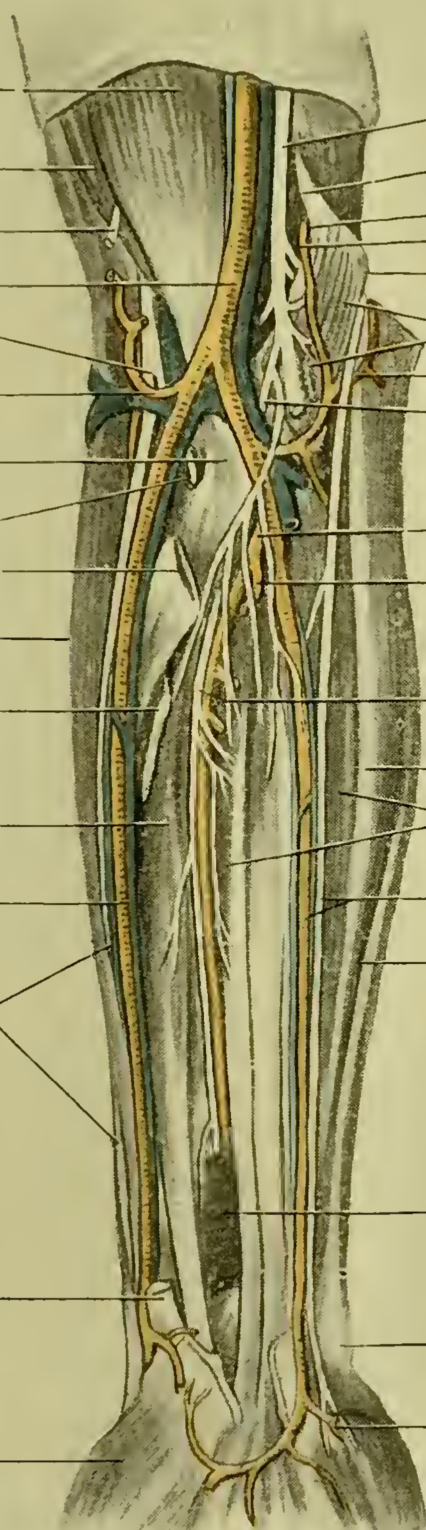

FIG. 56.—Deep dissection of front of forearm, the superficial flexors having been removed, the flexor carpi ulnaris detached from the inner condyle and reflected; the articular branches of the median are seen as the first branches of that trunk.

making the thumb point upward; placing the forearm in the prone position and pulling upon the muscle will show that it can supinate the forearm to the same extent. Pulling upon the external upper part of the muscle will show also that it can flex the forearm.

The Extensor Carpi Radialis Longior (Fig. 55).—**Origin,** the lowest third of the external supracondylar ridge and the external intermuscular septum; **insertion,** the base of the metacarpal bone of the index-finger (Fig. 68); **nerve-supply,** the musculo-spiral nerve (sixth and seventh cervical); **action,** to extend and slightly abduct the wrist.

The tendon, passing across the dorsal aspect of the lower end of the radius (Fig. 69) to reach its destination, will be followed in dissecting the hand.

The Extensor Carpi Radialis Brevior (Fig. 55).—**Origin,** the external condyle of the humerus by the common tendon; **insertion,** the base of the metacarpal bone of the middle finger; **nerve-supply,** the posterior interosseous nerve (sixth and seventh cervical); **action,** to extend the wrist.

The tendon of this muscle accompanies that of the preceding over the dorsal aspect of the radius and will be followed later.

The Radial Artery.—From its **origin** at the apex of the antecubital fossa in the bifurcation of the brachial artery, the *antebrachial portion* of this vessel curves outward toward the radial side of the forearm and passes straight downward to the base of the styloid process of the radius, where it curves around the radial border of the wrist to pass under the tendons of the metacarpal extensor and the short extensor of the thumb, from which point its further course as the *carpal* and *palmar portions* of the vessel will be traced in the dissection of the hand. The **surface line** of the radial artery is, therefore, from the middle of the bend of the elbow to the ulnar side of the styloid process of the radius.

Beginning at its origin to clear the vessel of connective tissue, the dissector will first encounter among its branches the *radial recurrent artery* (Fig. 56) which has already been dissected (p. 98). Continuing he will encounter successively various *muscular branches* and at the front of the wrist the small *anterior radial carpal artery*, which passes inward beneath the flexor tendons to anastomose with the anterior ulnar carpal branch of the ulnar to form the *anterior carpal arch* (Fig. 65). The larger *superficialis volæ* branch, given off just before the artery curves around under the tendons above mentioned, passes downward across the thenar eminence to the palm and sometimes helps to form the superficial palmar arch (Fig. 61). In noting the **relations** of the radial artery, it will be seen to be overlapped in the upper two thirds of its course by the brachio-radialis muscle and to have the radial nerve upon its outer or radial side, the nerve being in intimate relation, however, only in the middle third. In the lower third it is covered by the skin and the superficial and deep fascia, and the radial nerve is no longer in relation with the vessel, having gone to the dorsal surface of the forearm. The artery is related on the inner side with the pronator radii

teres for a short distance above and with the flexor carpi radialis throughout the greater part of its length. It lies upon, first, the tendon of the biceps, then successively upon the supinator brevis, the pronator radii teres, the flexor sublimis digitorum, the flexor longus pollicis, the pronator quadratus and the lower end of the radius. The radial artery is accompanied by two veins.

The occasional *variation in the origin* of the radial artery is referred to on page 78. Rarely the vessel is *absent*, being replaced by an enlarged interosseous or by the comes nervi mediani. Sometimes passing to the dorsal surface of the forearm at a higher level than usual, it is replaced at the position of the "radial pulse" by the superficial volar.

The **radial nerve,** the origin and course of which are given on page 86, should now be completely isolated and traced to the point where it leaves the ventral aspect of the forearm, passing under the tendon of the brachioradialis to reach the dorsal aspect. For its distribution, see page 137.

The Median Nerve in the Forearm.—The nerve should be picked up in the antecubital fossa and, upon being followed downward, will be found to pass between the two heads of the pronator radii teres and under the tendinous arch connecting the radial and ulnar heads of the flexor sublimis digitorum, and thence downward beneath the mass of superficial flexors to the lower part of the forearm, where it lies between the tendons of the palmaris longus and the flexor carpi radialis. To expose the nerve more fully, the superficial head of the pronator radii teres should be divided near the inner condyle and the remaining flexors should be displaced toward the ulnar side of the forearm. The accompanying artery of the median nerve, the *comes nervi mediani*, a branch of the anterior interosseous artery, is occasionally present and may be of considerable size. When present it would be among the arteries requiring ligation in an amputation of the forearm.

The **branches** of the median nerve in the forearm are two small *articular* filaments to the elbow-joint (Fig. 71), the *anterior interosseous nerve*, *muscular branches* to all of the superficial group of flexors except the flexor carpi ulnaris, and the *palmar cutaneous branch* which arises a few inches above the wrist, as previously pointed out. The **muscular branches,** arising, for the most part, in common, near the elbow, should be first followed (Fig. 56).

The **anterior interosseous nerve** should then be traced as it passes beneath the deep part of the pronator radii teres to reach the anterior surface of the interosseous membrane. In its course down the forearm it is accompanied by the anterior interosseous artery. To expose these structures the superficial flexors must necessarily be cut or pushed aside, preferably the latter, and the flexor profundus digitorum must be drawn toward the ulnar side of the forearm and the flexor longus pollicis toward the radial side. The anterior interosseous gives *branches* to the flexor

longus pollicis, to the radial half of the flexor profundus digitorum, to the pronator quadratus, the upper border of which it is seen to enter (Fig. 56), to the interosseous membrane, to the radius and ulna (the branches accompanying the nutrient arteries) and to the wrist-joint. Thus the median nerve supplies all of the superficial flexors of the fore-arm save the flexor carpi ulnaris, and all of the deep muscles save the ulnar half of the flexor profundus digitorum.

The **anterior interosseous artery,** a branch of either the common interosseous or of the ulnar, should be worked out in connection with the anterior interosseous nerve which it accompanies. Traversing the anterior surface of the interosseous membrane to the upper border of the pronator quadratus, it divides into an *anterior* and a *posterior terminal* branch, the latter of which pierces the interosseous membrane and thus reaches the dorsal surface of the latter, where it communicates with the posterior interosseous artery (Fig. 69), while the anterior branch, passing over or beneath the quadrate pronator, communicates with the anterior carpal arch and with the palmar recurrent arteries (Fig. 65). Occasionally it is continued to the superficial palmar arch. The additional **branches** are the *comes nervi mediani*, usually a small vessel which accompanies the median nerve after its origin near the beginning of the anterior interosseous, although sometimes quite large (p. 111); *muscular* branches; and a *nutrient* branch to the radius.

The Ulnar Artery.—From its **origin** in the bifurcation of the brachial artery at the middle of the bend of the elbow, the ulnar artery curves inward toward the ulnar side of the forearm at the upper end of the middle third and then passes downward along the radial border of the flexor carpi ulnaris to pass into the palm over the anterior annular ligament on the radial side of the pisiform bone (Fig. 56). Only the *antebrachial portion* of the vessel or that part which is found in the forearm is under consideration at present. Its **surface line** is from the middle of the bend of the elbow to the ulnar side of the forearm at the upper end of the middle third, and prolonged from this point to the radial side of the pisiform bone. In the upper part of its course the artery is covered by the mass of superficial flexors. The dissector should follow the artery upward from its superficial position near the wrist to the point where it disappears under the flexors and then, displacing this mass of superficial flexors outward toward the radius, or inward toward the ulna, the artery may be followed upward to its source. In cleaning the surface of the vessel, the dissector must avoid injuring the branches and the **two venæ comites.** The palmar cutaneous branch of the ulnar nerve, sometimes represented by two trunks, usually clings closely to the artery and may be in relation with it throughout the lower two thirds of its course. The ulnar nerve lies upon the ulnar side of the artery to the same extent.

The **branches** of the ulnar artery in the forearm may now be traced in the order of origin. The small **anterior ulnar recurrent** has been already dissected (page 99), and its ramification in front of the inner condyle noted. The larger **posterior ulnar recurrent,** which sometimes arises in common with the preceding branch, passes upward and inward beneath the flexor sublimis digitorum to reach the space between the inner condyle and the olecranon through which it passes to ramify behind the inner condyle in association with the inferior profunda and anastomotica magna of the brachial (Fig. 71). The **common interosseous artery,** already mentioned, is a short, thick trunk (Fig. 56), which divides into the *anterior interosseous* and the *posterior interosseous*, the former of which has been dissected in connection with the anterior interosseous nerve (page 112), and the latter of which will be found in the dissection of the posterior surface of the forearm (page 142). The **nutrient branch** to the ulna arises in the upper part of the forearm and enters the nutrient foramen near the outer border of the bone. The **muscular branches** are given off along the course of the vessel. The **posterior ulnar carpal,** which arises a short distance above the wrist, curves around the inner surface of the ulna beneath the tendon of the ulnar carpal flexor to assist the posterior radial carpal artery in forming the *posterior carpal arch*. In following this vessel beneath the ulnar nerve to the dorsal aspect of the limb, the dorsal cutaneous branch of the ulnar nerve may be encountered. The **anterior ulnar carpal** branch, arising near the wrist, passes outward beneath the flexor tendons to unite with the anterior carpal branch of the radial to form the *anterior carpal arch*.

The **relations of the ulnar artery** may now be studied to better advantage, the vessel and its branches having been isolated. As previously noted, it is *covered*, above, by the superficial group of flexors with the exception of the flexor carpi ulnaris, and is crossed near its origin by the median nerve, while in its lower two thirds it is covered by the skin and fasciæ only, except for a slight overlapping above by the ulnar carpal flexor. It *lies upon* the brachialis anticus at its beginning and throughout the rest of its course in the forearm upon the deep flexor of the fingers. On its *ulnar side* are the ulnar nerve and the ulnar carpal flexor in its lower two thirds; on the *radial side* is the flexor sublimis digitorum.

The ulnar artery presents some interesting **variations** as to course and origin which are related to developmental peculiarities. The *high division of the brachial* (page 78) not only gives the ulnar artery greater length, but in such cases it may pass into the forearm in front of the inner condyle and over the superficial flexors.

The Ulnar Nerve in the Forearm.—The ulnar nerve should be picked up in the upper arm and traced to the interval between the olecranon and the inner condyle of the humerus, in which position it

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gives off two small branches to the elbow-joint. Separating the flexor carpi ulnaris, under which the nerve passes—having previously cut the humeral head of the muscle—from the remaining superficial flexors will expose the further course of the nerve down the ulnar side of the forearm on the ulnar side of the ulnar artery to its entrance into the palm of the hand over the anterior annular ligament (Fig. 56). The **branches** first given off, the **articular** filaments to the elbow-joint noted above (Fig. 71) should be identified, the nerve being displaced slightly and cautiously for the purpose. The **muscular branches** which it gives to the flexor carpi ulnaris will be found in the upper part of the forearm, as also the branch or branches to the ulnar half of the flexor profundus digitorum upon which muscle the nerve lies (Fig. 56). About four inches above the wrist it gives off the **dorsal cutaneous branch,** which passes round the ulnar border of the forearm beneath the ulnar carpal flexor to reach the dorsal surface on its way to the ulnar side of the dorsal surface of the hand, where it is distributed to the skin of the little finger and the adjacent side of the ring finger; the complete dissection of this branch must be deferred for the present. At some point below the middle of the forearm a **palmar cutaneous branch** is given off from the ulnar which diverges outwardly from the parent trunk but runs approximately parallel with it to the palm, accompanying, and very intimately related with, the ulnar artery to which it gives branches. It is sometimes double.

The proximity of the ulnar nerve to the inner condyle of the humerus and the olecranon renders it liable to injury in fractures of the lower end of the humerus and in dislocations of the elbow-joint. Sharp flexion of the elbow-joint, as during surgical operations under anæsthesia, sometimes results in ulnar paralysis, the symptoms of which are pointed out on page 125.

The **deep group of flexor muscles** includes the flexor profundus digitorum, the flexor longus pollicis and the pronator quadratus.

The Flexor Profundus Digitorum (Fig. 56).—**Origin,** the upper three fourths of the anterior and of the inner surfaces of the ulna and the inner half of the interosseous membrane, the inner side of the coronoid process and by the common aponeurosis from the posterior border of the ulna; **insertion,** by four tendons into the palmar surfaces of the bases of the distal phalanges of the four fingers, each tendon perforating the corresponding tendon of the superficial flexor (Fig. 63); **nerve-supply,** the ulnar nerve and the anterior interosseous branch of the median (seventh and eighth cervical and first thoracic nerves); **action,** to flex the fingers, primarily their terminal phalanges, secondarily the first and second phalanges and finally the hand.

This muscle may be exposed by retracting the flexor carpi ulnaris toward the ulnar side of the forearm and the other superficial flexors toward the radial side. While it is desirable to defer the cutting of the

flexor sublimis digitorum until after its tendons shall have been followed to their terminations, it may be divided near its origin and reflected downward—to be subsequently replaced and stitched—if the dissector find the former method inconvenient. The four tendons in which the muscle bundles terminate at about the middle of the forearm pass under the anterior annular ligament, and will be followed to their terminations in the dissection of the hand.

The Flexor Longus Pollicis.—**Origin,** the upper three fourths of the anterior surface of the radius and the oblique line of this bone, the outer portion of the interosseous membrane, and occasionally from the inner side of the coronoid process of the ulna or the inner condyle; **insertion,** the base of the distal phalanx of the thumb; **nerve=supply,** the anterior interosseous branch of the median (eighth cervical and first thoracic); **action,** to flex the distal phalanx of the thumb, primarily, and the proximal phalanx and the hand secondarily (Fig. 56).

This muscle may be exposed by retracting the superficial flexors toward the ulnar side of the forearm and the lower part of the brachio-radialis toward the radial side, removing or reflecting the terminal portion of the pronator radii teres. The tendon of this muscle, passing under the anterior annular ligament, will be worked out in the dissection of the hand.

The Pronator Quadratus (Fig. 65).—**Origin,** the lower fourth of the anterior surface of the ulna; **insertion,** the lower fourth of the anterior surface of the radius; **nerve=supply,** the anterior interosseous branch of the median from the seventh and eighth cervical and first thoracic nerves; **action,** to pronate the forearm.

This muscle is easily exposed by displacing the tendons which pass over it. Its nerve enters either the deep or superficial surface near the upper border, and the anterior terminal branch of the anterior interosseous artery passes either over or through it.

THE PALMAR OR VOLAR SURFACES OF THE WRIST AND HAND.

As a preliminary to the dissection of the hand, the salient features of the bones of these parts should be reviewed. Among the points to be noted are the bones composing respectively the first and second rows of the **carpus** (Fig. 57), and the order in which they are found from without inward or the reverse, their relations to each other and their areas for muscular attachments. The peculiar situation of the pisiform bone, the tuberosity of the scaphoid, the ridge and groove of the trapezium and the unciform process of the unciform should likewise be noted.

The **metacarpus,** comprising the five metacarpal bones with their proximal heads and distal bases, the relation of the former to each other

and to the carpus, and of the latter to the phalanges must receive due attention, as must also the bones of the digits with their respective proximal, middle and distal phalanges for each digit except the thumb, which has but two phalanges.

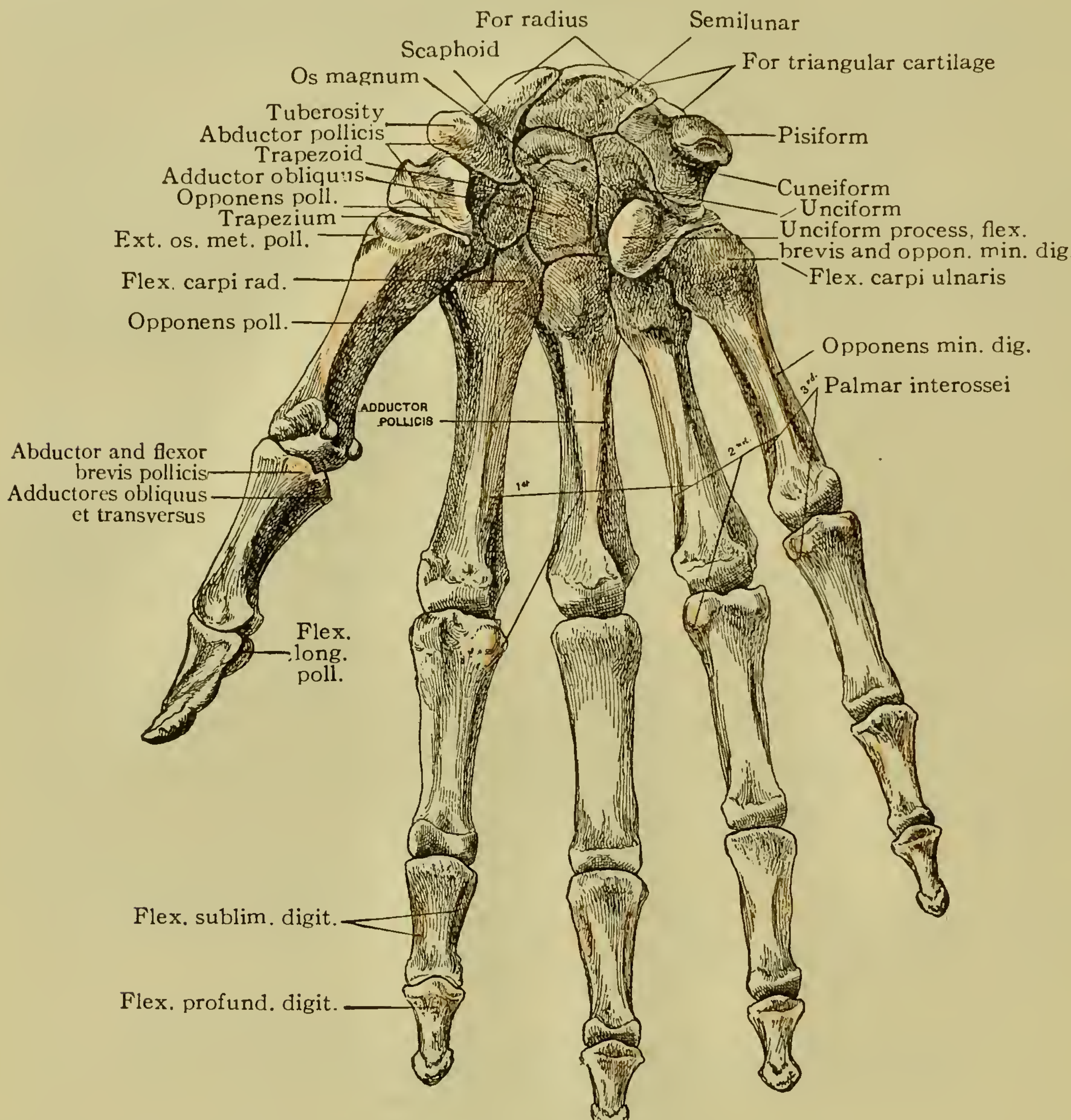

Fig. 57.—Bones of right hand, palmar aspect.

THE SURFACE ANATOMY.

The surface markings of these parts may be studied to best advantage in the living subject especially as the skin of the wrist has been to some extent disturbed in the dissection of the forearm.

The **volar surface of the wrist,** the hand being fully supinated, presents at its radial border a prominent ridge due to the tendon of the extensor of the metacarpal bone of the thumb and that of the short

extensor of the thumb. This is most in evidence in voluntary extension of the thumb and its metacarpal bone. The lower extremity of the radius and its styloid process are plainly recognizable by touch. The tip of the styloid process is one half inch lower or more distal than that of the ulna and corresponds with the outer extremity of the radio-carpal joint.

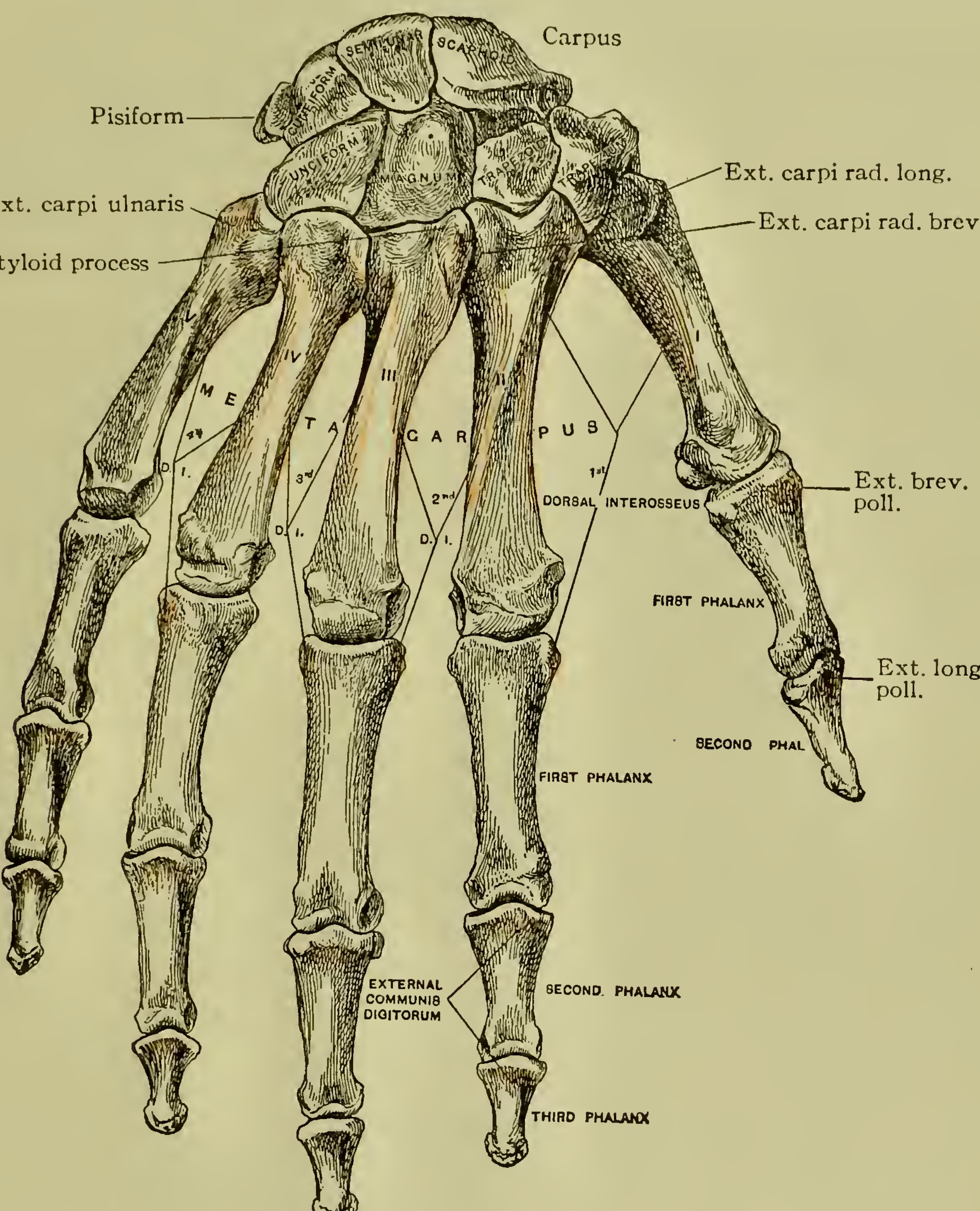

FIG. 58.—Bones of the right hand, dorsal aspect.

At the inner or **ulnar border of the wrist,** the head of the ulna is palpable, the palpating finger sinking into a depression below it, on the radial border of which depression is the tendon of the flexor carpi ulnaris made tense by flexion or by adduction of the wrist. This tendon leads downward to the pisiform bone, the first prominence below the head of the ulna. The unciform process of the unciform may be ob-

scurely palpated by deep pressure below and to the radial side of the pisiform. The tuberosity of the scaphoid and the ridge of the trapezium are recognizable as a prominence directly outward from the pisiform, to which the tendon of the flexor carpi radialis leads. The upper border of the anterior annular ligament is made evident between the pisiform and the scaphoid by forcible extension of the hand and abduction of the thumb. The tendons crossing the front of the wrist have been sufficiently considered (page 105). The transverse creases of the wrist are two or three in number. The more proximal one passes just below the head of the ulna and crosses the base of the styloid process of the radius. The more distal crease corresponds with the upper border of the anterior annular ligament and with a point about three fourths of an inch below the highest part of the wrist-joint.

The **palm of the hand** is marked on its radial side by a muscular prominence, the **thenar eminence,** due to the small muscles of the thumb; and on its ulnar side by the **hypothenar eminence** caused by the small muscles of the little finger (Fig. 39). Of the **furrows of the palm,** the most conspicuous begins at the radial side of the hand opposite the metacarpo-phalangeal joint of the index-finger and curves upward to terminate between the thenar and hypothenar eminences. This furrow is caused by flexion of the metacarpal bone of the thumb and by flexion of the index-finger. A second furrow diverges from this first one opposite the cleft between the first and second metacarpal bones, and passes transversely toward the ulnar side of the hand to terminate upon the hypothenar eminence. It indicates the lowest or most distal limit of the superficial palmar arch and is caused by flexion of the fingers. A third furrow begins opposite the cleft between the first and second fingers and extends transversely to the ulnar border of the hand, being parallel with the second. Its position is about one half inch on the proximal side of the metacarpo-phalangeal joints. A conspicuous fourth furrow connects the beginning of the third with the middle of the second, giving the form of the letter M to these creases. On the distal side of the third furrow are seen little elevations opposite the clefts of the fingers, due to the presence of fat between the tendons and the slips of the palmar fascia which bind the tendons down on the way to their respective fingers. The **transverse folds** across the fronts of the bases of the fingers are distinctly double in the case of the middle and ring fingers, while on the index- and little fingers the lower crease of the fold fades out at about the middle of the surface of the finger. These folds are nearly three fourths of an inch below the corresponding metacarpo-phalangeal joint and are at the level of the webs of the fingers. The corresponding fold of the thumb, beginning at the free edge of the web on a level with the metacarpo-phalangeal articulation, passes around to skirt the thenar eminence, crossing the line of the joint

obliquely. The joint-lines of the articulations between the proximal and middle phalanges are directly opposite the **double folds** found here, while the **single folds** farther down are slightly above the joints.

It will be noted that the form of the **metacarpal bones** is difficult to recognize by palpating the palmar surface of the hand, in marked contrast with the ease with which these bones may be recognized upon the dorsal surface. Between the metacarpal bone of the thumb and that of the index-finger is a mass which is composed dorsally of the first dorsal interosseous muscle or abductor indicis, and on the volar aspect of the transverse adductor of the thumb. At the apex of the triangular space formed by the metacarpal bone of the thumb and that of the index-finger the radial artery passes from the dorsal to the palmar aspect of the hand. The **skin** of the palm is notably thick and closely adherent to the underlying deep fascia, the superficial fascia being sparing in quantity, and is very plentifully supplied with sweat glands but is devoid of hair. The absence of superficial veins is noteworthy, the venous blood of the hand being carried away almost entirely by the superficial dorsal veins of the hand. The skin on the dorsal surface of the hand, which is rather thin, is loosely connected with the underlying fascia and is beset with hairs.

These differences are strikingly emphasized in the readiness with which the dorsal surface of the hand swells, as for example in œdema, owing to the looseness of the subcutaneous tissue, and the resistance toward this condition shown by the skin of the palm.

DISSECTION.

The hand should be secured in position by driving a nail or long tack through the extreme end of each finger and of the thumb as the hand lies supine. A median incision should be made through the palm and a transverse incision opposite the finger clefts. The skin should be reflected beginning at the wrist. In removing the skin from the central part of the palm, a dense fascia will be left, while in the lateral regions the underlying fascia is much thinner and, therefore, care must be exercised to avoid removing it with the skin. In carrying the dissection across the thenar eminence, the **superficialis volæ artery** should be looked for and, near the middle of the palm, the **palmar cutaneous branch of the median nerve** (Fig. 53). Reaching the proximal end of the thumb, a median incision may be made along its palmar aspect and the skin reflected toward either side, taking care not to injure the nerves and blood-vessels near the lateral portions of the volar surface. The index-finger and the ring finger should be treated similarly and with the same precautions as to wounding vessels and nerves. In reflecting the inner flap the **palmar cutaneous branch of the ulnar nerve** may be looked for and, as the ulnar side of the palm is approached, the **palmaris brevis muscle** (Fig. 59) will be found in the form of transversely

directed fibres mingled with the fat of the superficial fascia. This muscle takes its *origin* from the central part of the palmar fascia and the anterior annular ligament and is *inserted* into the skin on the ulnar side of the palm; it should be left in position. As the distal portion of the palm

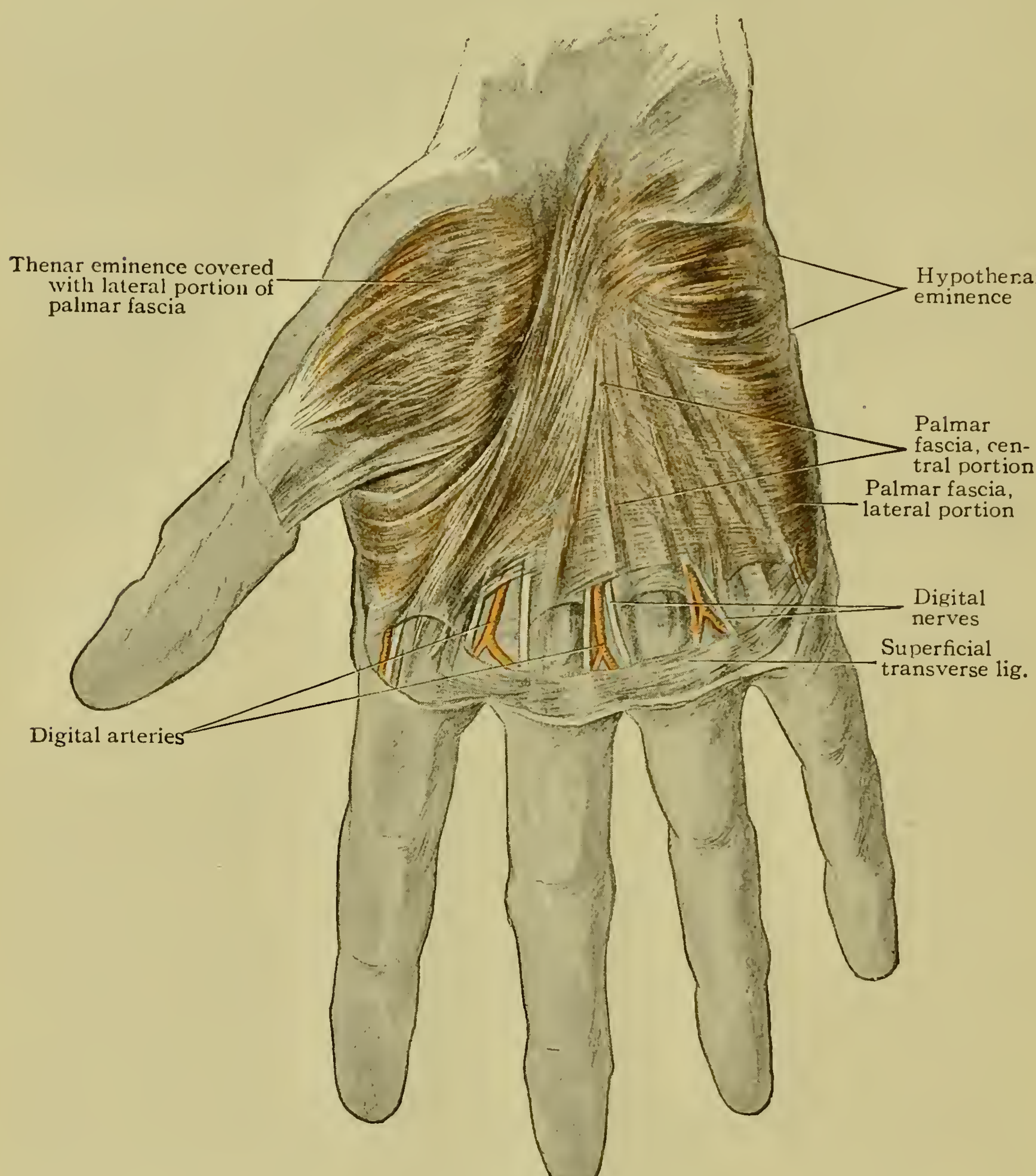

FIG. 59.—Superficial dissection of hand, showing palmar fascia.

is approached some of the digital nerves may be encountered appearing opposite the finger clefts between the bands into which the central part of the palmar fascia divides (Fig. 59). The dissector will have noted the close relation between the skin and the underlying deep fascia, which is left in position, by reason of the fact that the **superficial fascia** is

scant in quantity and is closely adherent to both the skin and the deep fascia. The connection between the skin and the deep fascia is especially close near the finger clefts owing to the presence of strong fibrous bands which connect the two. Any fragments or small masses of fat remaining upon the surface of the deep fascia should be removed so as to demonstrate the latter to the best advantage.

The Palmar Fascia (palmar aponeurosis).—The fascia thus exposed is seen to consist of a central and two lateral portions. The **central portion** is triangular in outline and is sharply differentiated from the **lateral portions** by its greater thickness and its consequent greater opacity. Narrow above, where it is continuous with the anterior annular ligament, it becomes widened distally and divides into **five processes or bands** corresponding to the five digits, the band for the thumb being less strongly marked than the others; between these bands emerge the digital arteries and nerves for the corresponding fingers (Fig. 59). The bands are connected with each other and with the skin by strong transverse fibres. Each one of these processes divides into two *portions* which pass respectively to the lateral aspects of the corresponding metacarpophalangeal joint and serve to bind down the tendons which pass under and between them to the corresponding fingers; and they send fibres backward also, to be attached to the lateral aspects of the distal extremities of the metacarpal bones. From each lateral border of the central portion of the palmar fascia a septum is continued into the deep parts of the palm, thus isolating the tendons, vessels and nerves which lie under this central part of the fascia.

The **superficial transverse metacarpal ligament** (Fig. 59) is a conspicuous aggregation of some of the fibres of the palmar fascia which stretches across the proximal ends of the fingers and is intimately connected with the skin.

This arrangement of the palmar fascia tends to confine collections of pus, *palmar abscess*, to the central portion of the palm and to prevent its coming to the surface, causing it rather to follow the tendons and their sheaths under the anterior annular ligament into the forearm; and even sometimes causing it to point on the dorsal surface of the hand rather than in the palm. The condition known as *Dupuytren's contraction* is a thickened, contracted state of the central slip of the palmar fascia, or of one or more of its digital slips, producing partial flexion of one or more fingers, due to long continued pressure, as by the handle of a chisel or other tool, in those of a gouty tendency.

The **lateral portions of the palmar fascia** cover respectively the muscles of the thenar and hypothenar eminences; these should now be removed, exposing these muscles, but leaving the central portion intact.

The **anterior annular ligament** (ligamentum carpi transversum, Fig. 60) is a strong fibrous band or sheet which is attached on the radial side to the scaphoid and the trapezium and on the ulnar side to the pisiform and the unciform process of the unciform. Continuous distally

with the palmar fascia and above with the deep fascia of the forearm, it binds down the tendons of the digits and is thus related in an important manner to their function. The canal which it forms gives passage to the tendons of the superficial and deep flexors of the fingers, to that of the long flexor of the thumb and to the median nerve. In clearing its surface the ulnar nerve and artery will be found as well as the palmar cutaneous branches of the ulnar and median nerves. As will be seen below, the anterior annular ligament affords partial origin to many of the small muscles of the hand.

Abductor Pollicis (Fig. 62).—**Origin,** the ridge of the trapezium and the annular ligament; **insertion,** the base of the first phalanx of the thumb on the radial side and the sheath of the extensor longus pollicis tendon; **nerve=supply,** the median nerve (sixth and seventh cervical); **action,** abduction and flexion of the thumb.

This muscle is the most superficial of the thenar group. Displacing it outward brings to view the opponens pollicis, while to its inner side is the short flexor of the thumb.

Flexor Brevis Pollicis.—**Origin,** the outer two thirds of the lower border of the annular ligament; **insertion,** the radial side of the base of the first phalanx of the thumb in company with the abductor; **nerve=supply,** the median nerve (sixth and seventh cervical); **action,** to flex the thumb.

The tendon of the long flexor of the thumb passes between this muscle and the adductor pollicis near their insertions after having passed beneath the short flexor. A sesamoid bone is found in the tendon of insertion of this muscle (Fig. 73). What is given above as the short flexor of the thumb has usually been described as the *outer head* of the muscle, its *inner head* having been regarded as the small fasciculus which *arises* from the ulnar side of the base of the first metacarpal bone and *inserts* into the ulnar side of the base of the first phalanx. This fasciculus, which is more deeply placed, is looked upon by German anatomists as a palmar or volar interrosseous muscle for the first intermetacarpal space, since it corresponds in origin and insertion with the other palmar interosseous muscles.

Dorsal dislocation of the proximal phalanx of the thumb is reduced usually with considerable difficulty, owing, it is thought by some, to the fact that the short flexor and the oblique portion of the adductor pollicis, (or the two heads of the short flexor, according to the older nomenclature), being carried dorsally by the phalanx and thereby made tense, closely grasp the distal extremity of the metacarpal bone and so resist reduction.

Opponens Pollicis.—**Origin,** the trapezium and the annular ligament; **insertion,** the radial side of the first metacarpal bone (Fig. 64); **nerve=supply,** the median nerve (sixth and seventh cervical); **action,** to flex the metacarpal bone or to "oppose" it to the ulnar side of the hand.

These muscles are to be worked out as well as the present state of the dissection will permit, that is, without disturbing the central portion of the palmar fascia. After the removal of the latter, they can be examined more fully and the adductor pollicis will be dissected (p. 133).

The **hypothenar muscles** on the ulnar portion of the palm are now to be isolated and studied.

Abductor Minimi Digiti.—**Origin,** the pisiform bone and the annular ligament; **insertion,** the ulnar side of the base of the proximal phalanx of the little finger; **nerve-supply,** the ulnar nerve (eighth cervical and first thoracic); **action,** to abduct the little finger from the ring finger. Displacing this muscle slightly will disclose upon its outer side the flexor brevis minimi digiti. Between these two near their origin the deep branch of the ulnar nerve and the deep palmar branch of the ulnar artery will be found passing to the deep part of the palm (Fig. 62).

Flexor Brevis Minimi Digiti.—**Origin,** the unciform process of the unciform bone and the anterior annular ligament; **insertion,** the ulnar side of the base of the proximal phalanx of the little finger; **nerve-supply,** the ulnar nerve (eighth cervical and first thoracic); **action,** to flex the little finger.

Opponens Minimi Digiti.—**Origin,** the unciform bone and the annular ligament; **insertion,** the entire ulnar border of the fifth metacarpal bone; **nerve-supply,** the ulnar nerve (eighth cervical and first thoracic); **action,** to flex and adduct the metacarpal bone of the little finger. This muscle is to be exposed by displacing the two preceding muscles (Fig. 61).

The Deeper Structures of the Palm.—With the central portion of the palmar fascia in position, note should be made of the fact that the tendons of the superficial and deep flexors pass from the palm to the fingers under tendinous arches formed by the bifurcation of each one of the individual slips of the central portion of the fascia, while the digital nerves and vessels pass to the fingers through the intervals between the individual slips (Fig. 59). The central portion of the palmar fascia should now be incised at its proximal extremity and the lateral septa which bind the borders of it down should also be divided and the fascia reflected toward the fingers, exposing the deeper structures.

The **carpal portion of the ulnar artery,** lying upon the anterior annular ligament, gives off no named branches.

The **palmar portion of the ulnar artery** passes beneath the palmar fascia and arches across the hand to terminate by anastomosing with either the radialis indicis of the radial artery or its superficial volar branch.

The **branches** of the palmar portion of the ulnar are **cutaneous** and **muscular** branches, the **deep branch** or branches and the **digital** branches. The **deep branch,** arising near the lower margin of the

annular ligament, passes between the short flexor and the abductor of the little finger (Fig. 60) to communicate with the deep palmar arch.

The **superficial palmar arch** lies upon the flexor tendons, describing an arch which is convex downward, the lowest point of the arch being on a level with the lower border of the outstretched thumb (Fig. 60). The superficial arch is formed by the termination of the ulnar artery anastomosing with a branch from the radialis indicis artery or sometimes

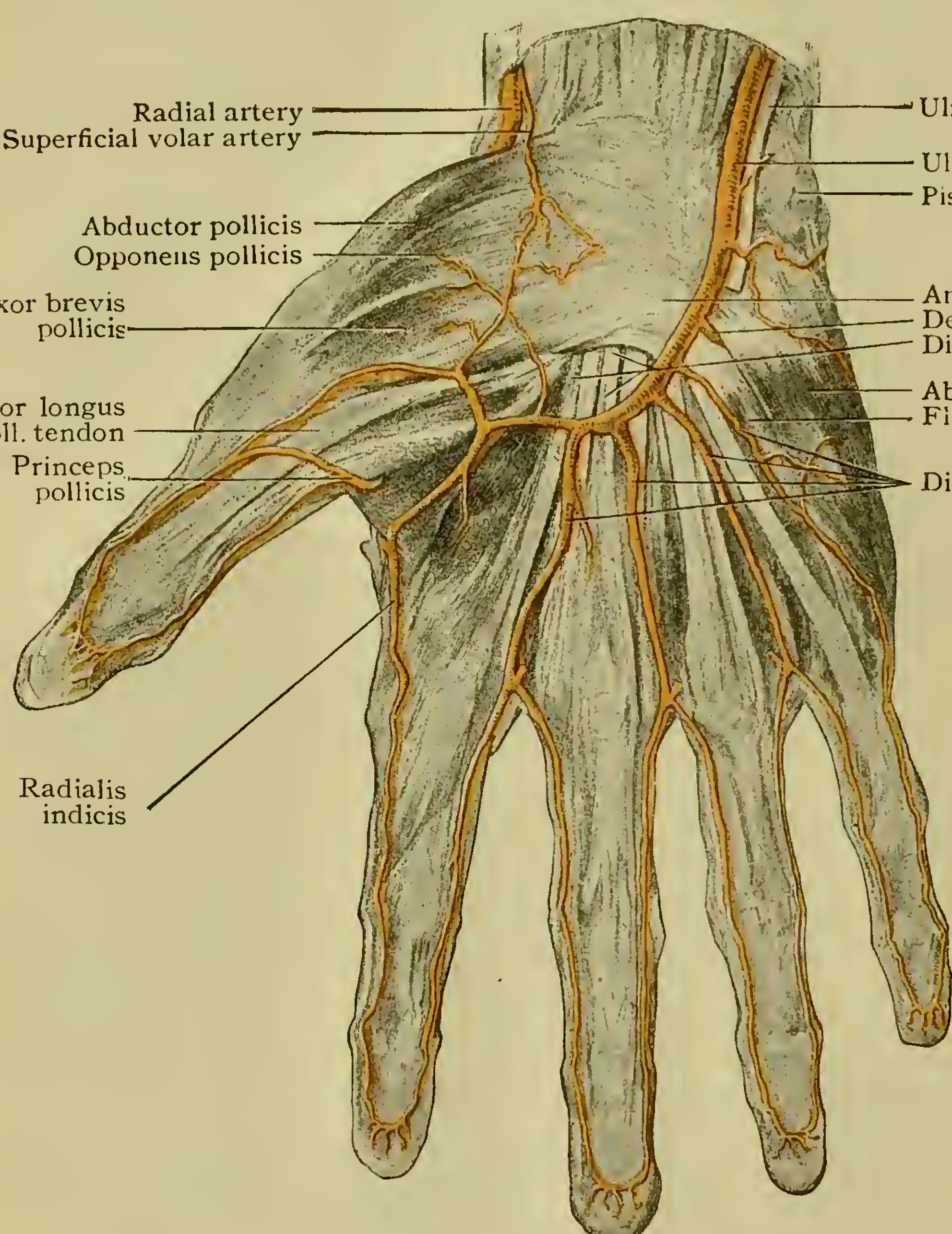

FIG. 60.—Superficial palmar arch and its branches.

with the superficialis volæ. The arch should now be denuded of connective tissue and its **digital branches,** given off from its convexity, should be traced downward, the **first** one, beginning on the ulnar side, going to the ulnar side of the little finger, the **fourth** one going to the adjacent sides of the index- and middle fingers. As will be seen later, the radial side of the index-finger is supplied by the radialis indicis from the radial, and both sides of the thumb by the princeps pollicis from the radial.

These vessels should be followed to the fingers, when it will be seen that each digital, prior to its *division* at the finger cleft into *two collateral digitals*, is joined by a small vessel, the interosseous artery, from the deep palmar arch.

The dissector may find considerable **variation** from the arrangement of the superficial arch and its branches as here described. Thus, the *digital* branches may be unduly small, owing to enlargement of the interosseous arteries; or the arch may be formed entirely by the ulnar artery without the aid of any branches from the radial; or the superficial volar may independently supply the first digital branch on the radial side, the ulnar alone or with the aid of either the anterior interosseous or the median artery (a. comes nervi mediani) supplying the remaining digitals.

Wounds of the palmar arch are likely to be attended by very free bleeding which may be difficult to control on account of the communication of this arch with the deep one.

The **ulnar nerve** (pp. 76 and 113), entering the palm over the anterior annular ligament with the ulnar artery, should now be picked up by the side of the pisiform bone, when it will be seen to divide in this situation into a **superficial branch** and a **deep branch** (Fig. 61). The **superficial branch** gives off *two digital branches* which supply the ulnar side of the little finger, and the adjacent sides of the little and ring fingers as indicated above; it also supplies the palmaris brevis muscle. The **deep branch** passing downward between the abductor and the short flexor of the little finger, giving *branches* to both of these muscles, is distributed still further to the opponens minimi digiti, to the two inner lumbrical muscles, the palmar and dorsal interossei and to the adductor of the thumb—that is, the adductor as comprising what are also styled the oblique and transverse adductors and the deep head of the flexor brevis pollicis. These will be followed out more easily at a later stage of the dissection than at present.

The **distribution of the ulnar nerve** is thus seen to be cutaneous and muscular, the **cutaneous part** of the nerve supplying the little finger and the adjacent side of the ring finger through its two digital branches, and also the dorsal surfaces of the same fingers through its dorsal cutaneous branch (see page 138), and to assist in supplying the skin of the palm through its palmar cutaneous branch and a few small cutaneous branches to the ulnar border of the hand. The **muscles** supplied by the ulnar nerve are, in the forearm, the flexor carpi ulnaris and the ulnar half of the flexor profundus digitorum; and in the hand, the muscles of the hypothenar eminence, the interosseous muscles, the two inner lumbricales and the adductor pollicis (Fig. 64).

In **ulnar paralysis** we therefore find impairment of action of these muscles as indicated by difficulty in grasping and holding objects and, as a conspicuous sign, wasting of the palm of the hand due to atrophy of the interosseous muscles.

The **median nerve** (pp. 77 and 111) should be picked up as it passes from beneath the annular ligament and its various **branches** should be

traced. There will be **four** or sometimes **five digital branches** (Fig. 61) passing respectively to the adjacent sides of the ring and middle fingers, to the adjacent sides of the middle and index-fingers and to the radial

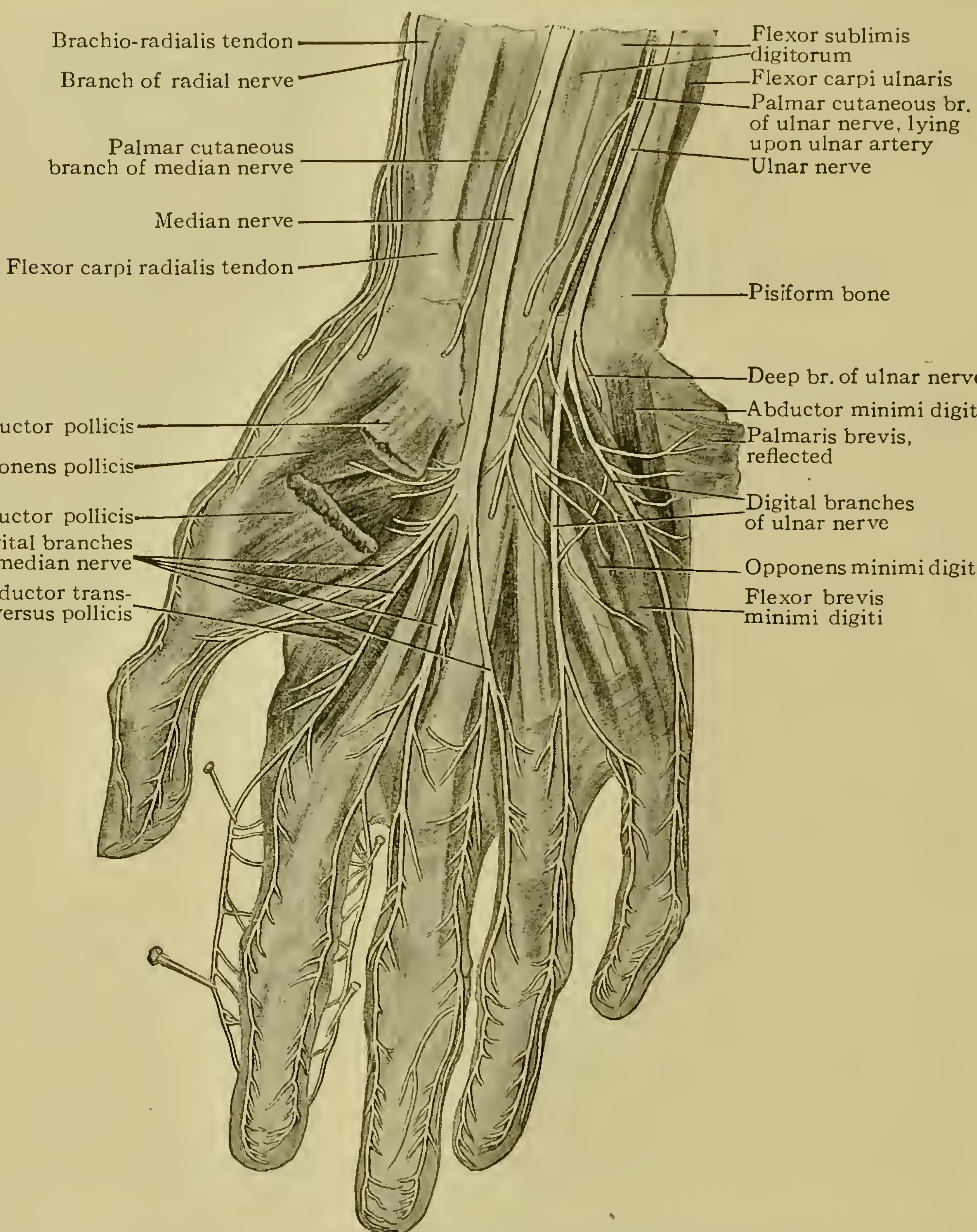

Fig. 61.—Superficial dissection of right palm, showing branches of median and ulnar nerves; part of anterior annular ligament has been removed to expose median nerve.

side of the index-finger, with one or two branches to supply the two sides of the thumb. **Muscular branches** pass to most of the small muscles of the thumb, namely the abductor, opponens, and the flexor brevis pollicis and also to the two outer lumbrical muscles.

The **distribution of the median nerve** is seen to be, therefore, **cutaneous** and **muscular;** its **cutaneous** distribution being the skin of the palm through its palmar cutaneous branch (see page 102) and three and one half digits, beginning with the thumb, on the palmar surface and to a considerable extent on the dorsal surface; its **muscular** distribution is to all of the superficial and deep flexors of the forearm except the ulnar half of the flexor profundus and the flexor carpi ulnaris, while in the palm it supplies less muscles than the ulnar nerve, giving branches only to those muscles of the thumb and the two lumbricales mentioned in the preceding paragraph.

Paralysis of the median nerve—rare except as the result of injury—is characterized by impairment or loss of pronation of the forearm and impairment of flexion of the wrist, the ulnar carpal flexor, supplied by the ulnar nerve, doing the work; inability to flex the second and third phalanges of the index and middle fingers, this function not being entirely lost in the little and ring fingers owing to the innervation of the ulnar half of the deep flexor by the ulnar, and flexion of the proximal phalanges being preserved by the action of the interossei, which are likewise innervated by the ulnar nerve; loss of abduction, flexion and of the opposing function of the thumb.

The tendons of the superficial flexor of the fingers should now be raised and drawn aside exposing the tendons of the deep flexor and the associated lumbricales muscles.

THE LUMBRICALES.—The lumbricales (Fig. 62) are four slender delicate muscles which take their **origin** from the tendons of the deep flexor. The first and second, on the radial side, arise from the radial side of the index-finger and middle finger tendons, respectively, while the third and fourth take their origin in each case from the adjacent sides of the tendons between which they lie, that is, from the second and third, and the third and fourth tendons respectively. Each muscle terminates distally in a slender tendon which passes to the radial side of the finger to which it belongs, being **inserted** into the aponeurosis of the extensor tendon on the dorsal aspect of the proximal phalanx. There is thus a lumbrical muscle for each of the four fingers. The **nerve-supply** of the first and second is from the median nerve; of the third and fourth, from the deep branch of the ulnar. The **action** is to flex the proximal phalanges of the fingers while aiding in the extension of the second and third phalanges by reason of their insertion into the aponeuroses of the extensor tendons.

As it is undesirable to cut the tendons of the deep and superficial flexor muscles until they shall have been traced to their terminations, the dissection of the remaining structures of the palm must be deferred until after the completion of the dissection of the fingers.

THE PALMAR SURFACES OF THE FINGERS.—A median incision should be made along the palmar surface of each finger and the skin and subcutaneous tissue should be dissected in each case toward each

border of the digit. The digital nerves and vessels (Fig. 61) will be found near the borders of the fingers, the nerves being superficial to the arteries, and should be identified and cleaned as the borders are approached. In working toward the finger clefts the delicate tendons of the lumbrical muscles on the radial sides of the respective fingers should be regarded in order that they may not be injured.

The **digital arteries** are nearer the margins of the fingers than the corresponding nerves. Each digital artery or, more properly, each collateral digital artery, as here encountered, is a branch of the digital artery proper, which latter bifurcates at the finger cleft into the collateral digitals for the adjacent margins of neighboring fingers (Fig. 60). At the tip of the finger the collateral digital anastomoses with the branch on the opposite side of the same finger to form a *vascular arch* from the convexity of which small branches are given off to the tip of the finger.

The **digital nerves,** which lie nearer the middle of the finger, are in like manner branches of digital nerves which bifurcate at the finger clefts. The digital nerves of the little finger and of the ulnar side of the ring finger are branches of the superficial division of the ulnar nerve (Fig. 61), while all the other digital nerves are branches of the median nerve. These digital nerves not only supply the skin of the palmar surfaces of the fingers, but send some branches to aid in supplying the dorsal surface, particularly in the case of the middle finger.

The Tendons and their Sheaths.—After the nerves and vessels have been thus worked out, the tendons and their sheaths should receive attention. In the case of one of them, as, for example, the little finger, all loose connective tissue should be removed in order to expose the sheath of the tendons (Fig. 62). This sheath is dense and fibrous and presents a glistening appearance. In the case of the index-finger a similar dissection should be made and should be supplemented by dissecting away the sheath of the tendon in the positions corresponding to the phalanges, leaving the transverse band opposite the joints, as shown in Fig. 62. This demonstrates the reinforcement of the tendinous sheaths opposite the joints by transverse bands. In the case of the middle finger these transverse bands should be removed with the remaining parts of the fibrous sheath, when the synovial membrane lining the sheath will be brought to view, and this may be incised and removed, exposing the tendons completely (Fig. 62). It will then be seen that the tendon of the superficial flexor lying on top at the metacarpophalangeal joint divides into two slips between which passes the tendon of the deep flexor. The two slips of the superficial flexor then unite under the tendon of the deep flexor, forming a sort of groove for it, and divide again to be **inserted** into the sides of the second phalanx (Fig. 62). The tendon of the deep flexor passes on to be **inserted** into the base of the distal phalanx. In the case of the ring finger the dissection may be

carried to a still further stage, as shown in Fig. 62, demonstrating the **vincula tendinum** or little bands which connect the tendon of the deep flexor with the under part of its sheath and with the superficial tendon; this may be also demonstrated by raising the tendon before its division.

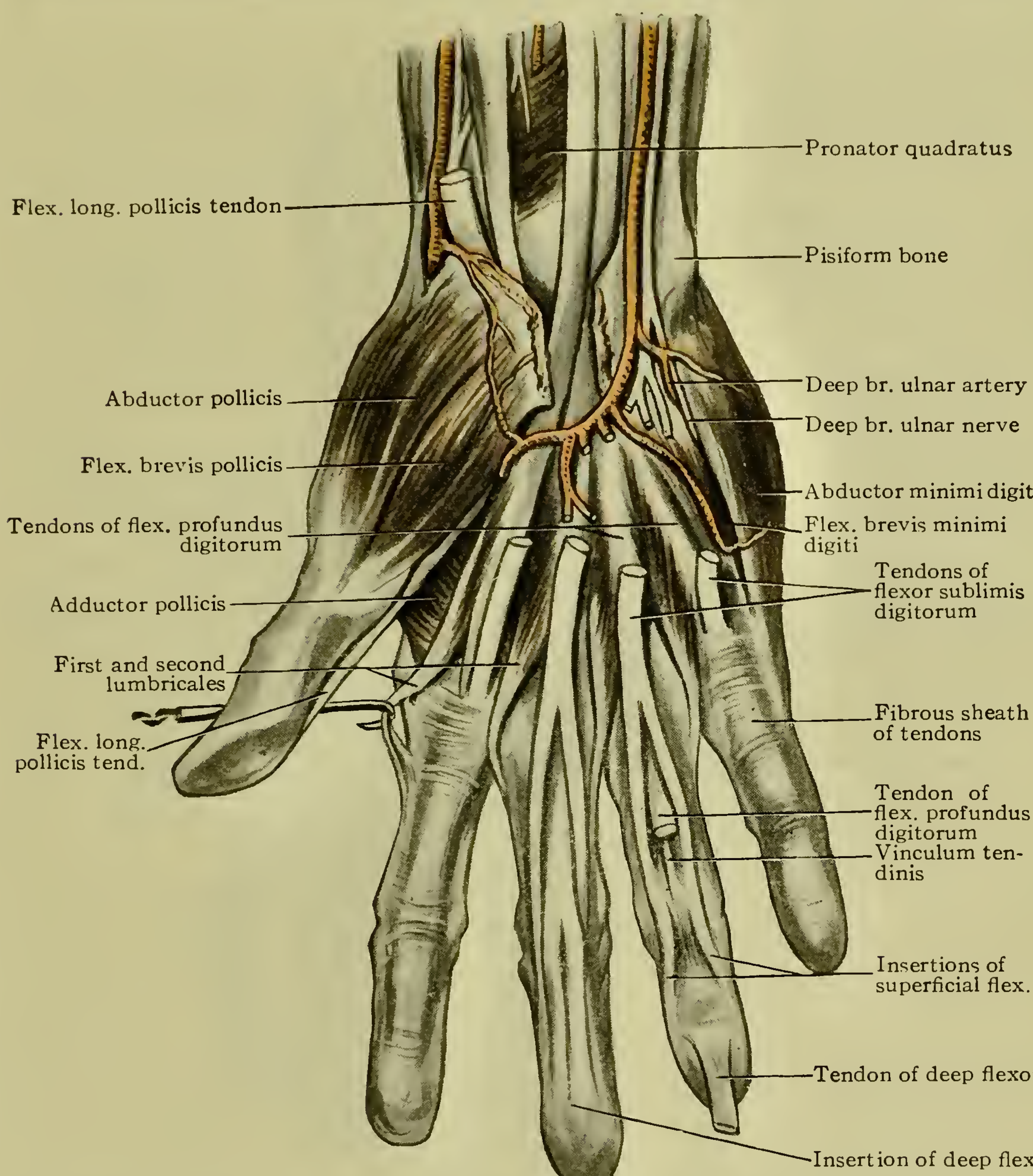

FIG. 62.—Dissection of palm of hand showing arrangement of the digital flexor tendons, their insertions and their digital sheaths.

Inflammation, attended with suppuration, in the soft tissue of the pulp of the finger constitutes what is sometimes called a *superficial whitlow*, in contradistinction to the deep or tendinous whitlow, which is a suppurative inflammation of the sheath of one of the tendons. Both these affections are sometimes called *felons* and if the inflammation extend deeply, involving the periosteum and bone, the disease is called a *bone-felon*. *Teno-synovitis* or thecitis (*theca*, a sheath) is a term also

applied to inflammation of a tendon-sheath and is usually restricted to the non-suppurative type of inflammation.

Before the sheaths of the tendons are opened, it may be demonstrated by injecting them that the sheaths of the index-, middle and ring fingers are interrupted a short distance above the metacarpo-phalangeal joints so that the injeetion goes no

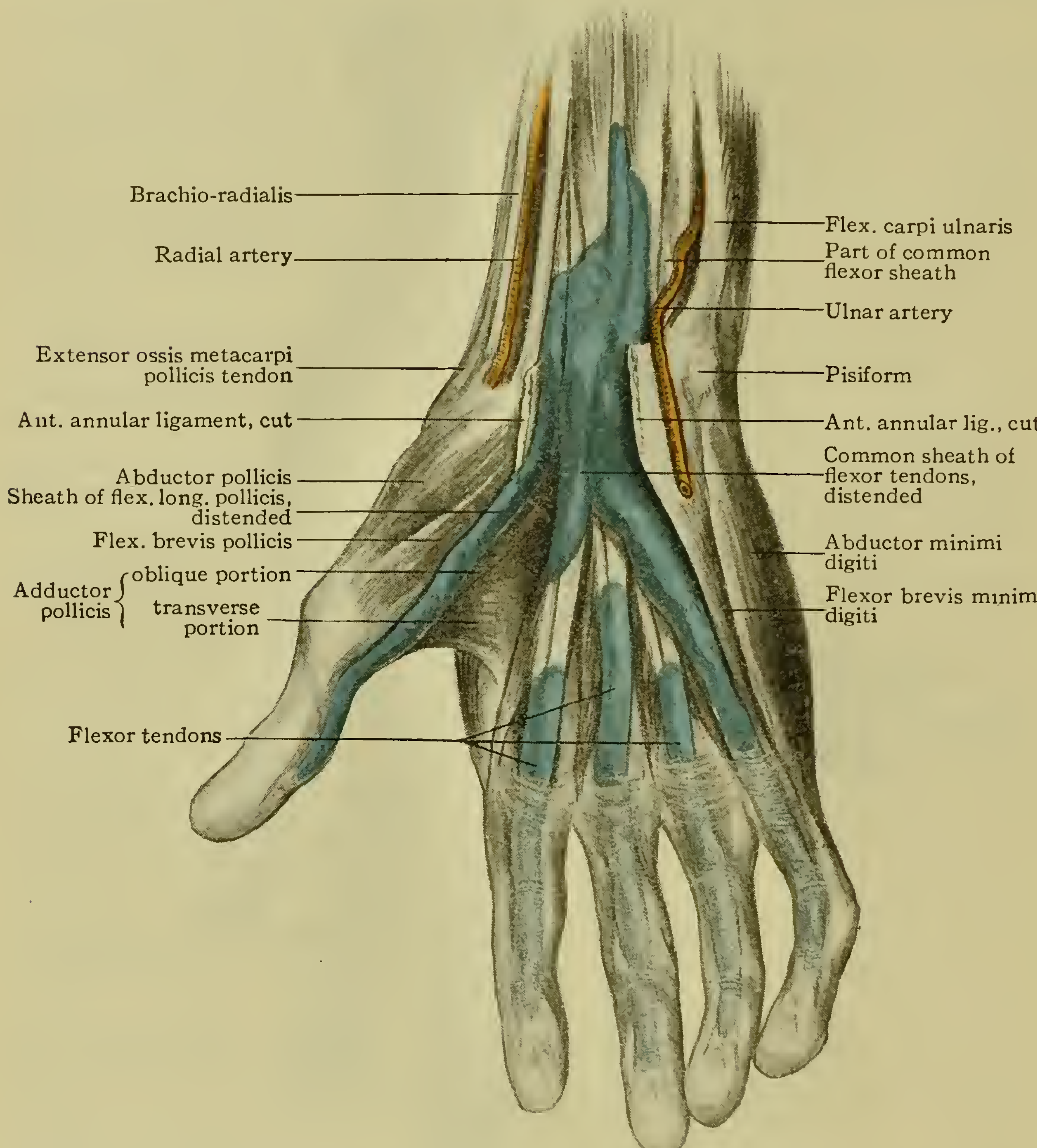

FIG. 63.—Dissection of palm of hand, showing sheaths of flexor tendons artificially distended.

farther (Fig. 63); while on the other hand, in the case of the thumb and the little finger, the injeetion will travel up through the palm under the anterior annular ligament into the lower part of the forearm (Fig. 63). From this it follows that abseess of the thumb or little finger tendon sheaths will be more apt to spread upward into the forearm than will be the ease with abseess of the other three sheaths. In ineising a felon or whitlow it will be apparent that the digital artery will best be avoided by avoiding the lateral border of the finger.

The flexores sublimis and profundus digitorum should be reviewed in their entirety, now that their tendons have been followed to their terminations, after which the tendons are to be removed from the palm

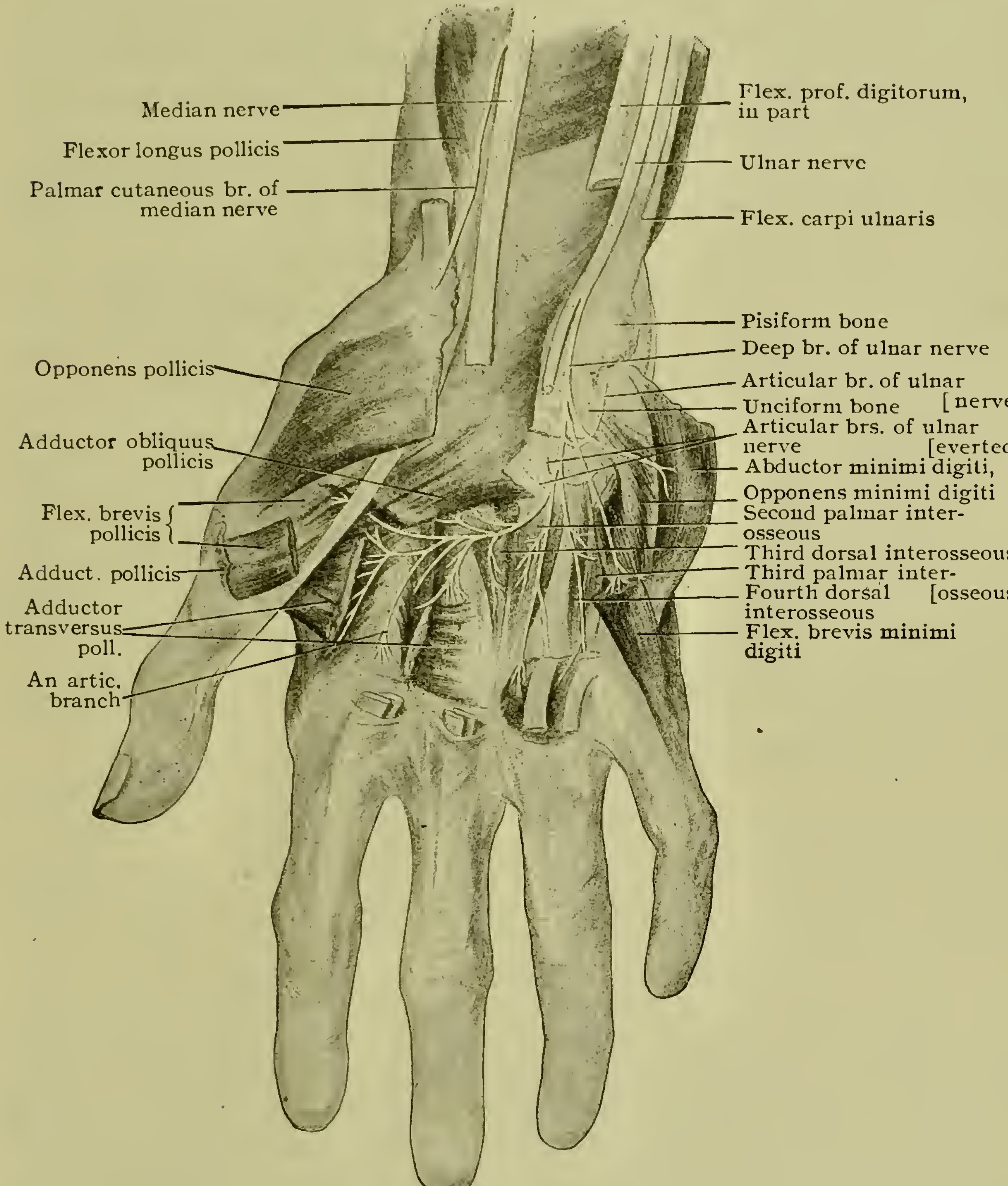

FIG. 64.—Dissection of right palm, showing distribution of deep branch of ulnar; flexor tendons of third and fourth fingers, with corresponding lumbricales, divided and turned down.

either by retracting them, cutting them, or by reflecting the entire muscles after dividing them in the forearm.

THE DEEP PALMAR ARCH (arcus volaris profundus).—The deep palmar arch will now be seen lying upon the bases of the metacarpal

bones and the interosseous muscles. The **position of this arch** is indicated by a line across the palm a finger's breadth nearer the wrist than the line of the superficial arch. It is formed by the termination of the palmar portion of the radial artery anastomosing with the deep or communicating branch of the ulnar artery. In noting its **relations,** it is seen to be separated from the superficial arch by the tendons of the deep and superficial flexors and to lie upon the bases of the metacarpal bones and the interosseous muscles.

The **branches** of the deep arch are the **palmar interosseous arteries,** three in number, which pass along the intervals between the metacarpal

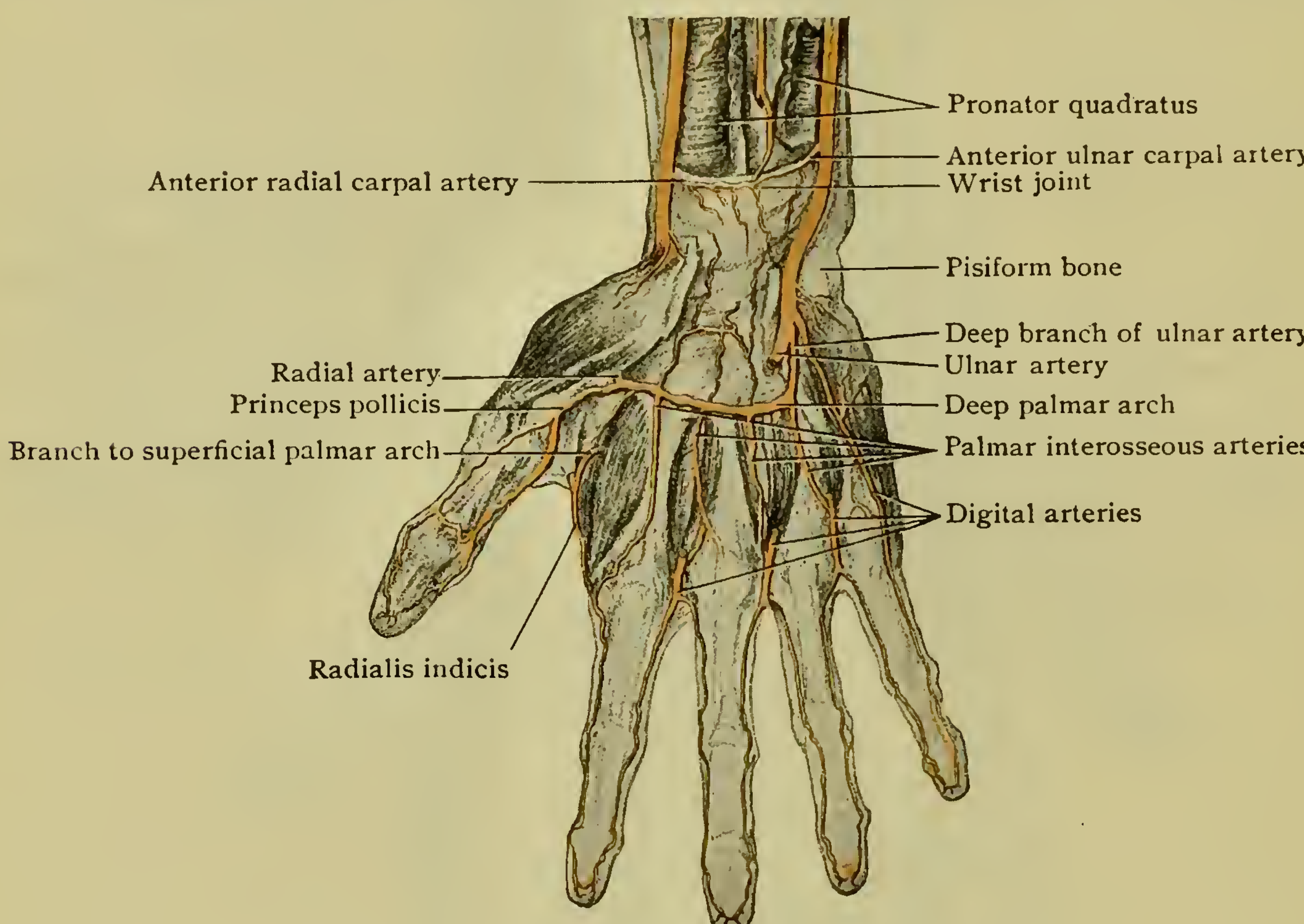

Fig. 65.—Deep arteries of the hand; flexor surface.

bones upon the interosseous muscles to the finger clefts, where they terminate by uniting with the corresponding digital branches of the superficial arch; the three **perforating branches,** either from the arch itself or from the interosseous branches, which pass through the clefts between the metacarpal bones to communicate with the arteries on the dorsum of the hand; and the small **palmar recurrent branches,** from the concavity of the arch, which pass upward to communicate with the anterior carpal arch and the anterior carpal network.

The **palmar portion of the radial artery** should now be followed from the radial extremity of the arch, toward the radial side of the hand beneath the adductor of the thumb to the interval between the two heads of the first dorsal interosseous muscle (Fig. 66).

The **branches** of the palmar part of the radial are the *princeps pollicis*, the *radialis indicis* and the branches noted above as arising from the deep arch. The **principal artery of the thumb** will be found springing from the radial just as that vessel perforates the abductor indicis; it should be followed in its course between the abductor indicis and the adductor pollicis along the ulnar side of the metacarpal bone of the thumb to its *division*,opposite the metacarpo-phalangeal articulation, into *two branches* (Fig. 65) which pass along the radial and ulnar borders of the thumb after the manner of the collateral digitals. The **radialis indicis,** arising a little later than the princeps pollicis, should be traced through the same muscular interval toward the radial side of the index-finger along which it is distributed; the *branch* which it usually contributes to the superficial palmar arch (Fig. 60) has been previously dissected.

From the position of the deep arch it will be seen that it could be more readily ligated, if wounded, by approaching it from the dorsal surface of the hand, one or more metacarpal bones being resected for this purpose, than by operating through the palm. Hemorrhage from a wounded deep arch or a wounded superficial arch has been referred to as being difficult to control on account of the numerous connections with other vessels. The superficial arch being connected with the deep by the connections between the palmar interosseous arteries and the digitals at the finger clefts and being connected with both the anterior and posterior carpal arches and consequently with the anterior and posterior interosseous vessels, both which latter derive their blood from the beginning of the ulnar artery, it will be seen that even ligation of both ulnar and radial arteries in the forearm would not suffice to control the bleeding, but that ligation of the brachial artery would be necessary.

The deep branches of the ulnar nerve (p. 125) should now be worked out if this has not already been done.

Adductor Pollicis (Fig. 63).—*Transverse portion* (adductor transversus pollicis): **origin,** the shaft of the third metacarpal bone (Fig. 62); **insertion,** the ulnar side of the base of the first phalanx of the thumb. *Oblique portion:* **origin,** the trapezium, trapezoid, os magnum and the bases of the second and third metacarpals; **insertion,** the ulnar side of the base of the first phalanx of the thumb and, by a small slip which passes obliquely under the long flexor tendon, into the radial side of the first phalanx with the flexor brevis, the tendon of insertion of the former portion usually containing a sesamoid bone; **nerve-supply,** the ulnar nerve (eighth cervical and first thoracic); **action,** to adduct the thumb.

The relation of this muscle to the princeps pollicis and radialis indicis branches of the radial artery has been seen in the dissection of that vessel.

The tendon of the long flexor of the thumb and its position between the flexor brevis pollicis and the adductor should also be examined.

Interossei Palmares Seu Volares.—These muscles (Fig. 66) are four in number, counting as the first, on the radial side, what is often designated the *deep head of the flexor brevis pollicis* (p. 122). **Origin,** the first and second, counting from the radial side of the hand, from

the ulnar sides of the first and second metacarpal bones, respectively; the third and fourth from the radial sides of the fourth and fifth metacarpals; **insertion,** the first, into the ulnar side of the base of the first

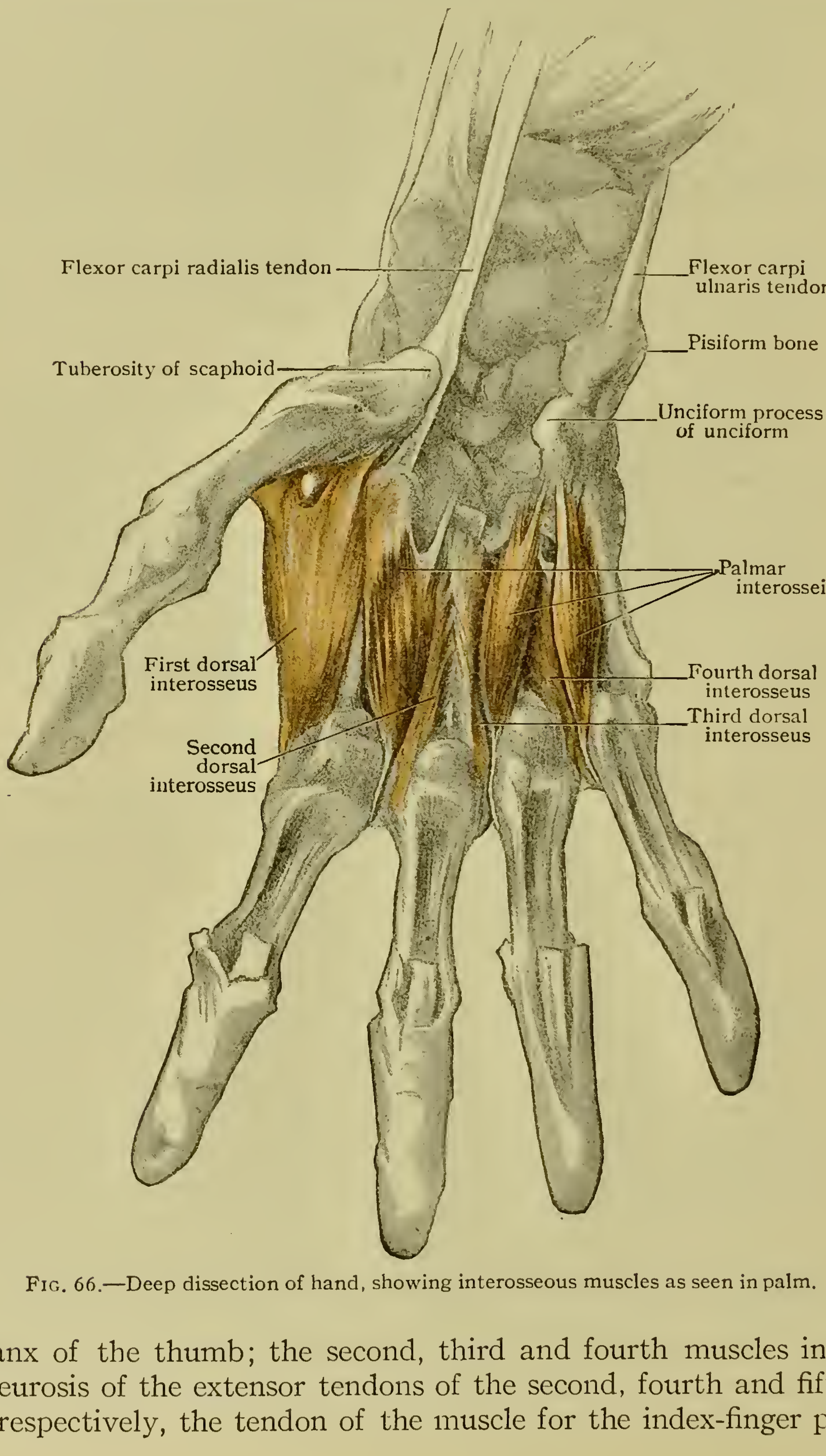

Fig. 66.—Deep dissection of hand, showing interosseous muscles as seen in palm.

phalanx of the thumb; the second, third and fourth muscles into the aponeurosis of the extensor tendons of the second, fourth and fifth fingers respectively, the tendon of the muscle for the index-finger passing

to the ulnar side of the digit, while the third and fourth tendons pass to the radial sides of their digits. It will be observed that neither the third metacarpal bone nor its corresponding digit is concerned with these muscles. The action of the volar interossei is, therefore, to adduct the fingers toward the middle line of the middle finger and to flex the proximal and extend the middle and distal phalanges. These muscles should be cleaned and isolated, when their relation with the dorsal interosseous muscles will be apparent. The latter are seen upon the palmar surface as here shown, since they lie between the metacarpal bones, rather than upon the dorsal surface. (See page 146.)

The tendon of the flexor carpi radialis lying in the groove on the trapezium as it passes to be inserted into the second metacarpal bone should be inspected (Fig. 73).

THE DORSAL SURFACE OF THE FOREARM, WRIST AND HAND.

THE SURFACE ANATOMY.

The Dorsal Surface of the Forearm.—The **olecranon process of the ulna** is plainly felt at the upper extremity of the forearm and on either side of this the **two condyles of the humerus** (page 92) form conspicuous prominences. Below the outer condyle a dimple indicates the position of the **head of the radius** (page 96), which may be felt to rotate here in pronation and supination of the forearm. The importance of the relation of the olecranon to the condyles has been pointed out (page 95). From the olecranon process the finger may readily follow the posterior border of the **shaft of the ulna,** which is practically subcutaneous, to its lower extremity, where its **styloid process** may be felt at the posterior and inner aspect of the wrist when the forearm is in the position of supination; in pronation, the styloid process of the ulna is at the opposite side of the wrist. The **shaft of the radius** is somewhat masked in the upper part of the forearm by the muscles which cover it, but is palpable in the lower half or two thirds, the **styloid process** being easily felt at the outer side of the lower extremity.

The student should study on the living subject the muscular and tendinous ridges which are evident upon alternate flexion and extension of the fingers and of the wrist. On the upper half of the dorsal surface of the forearm, with the latter in the supine position, an oblong swelling may be noted, on the ulnar side of the groove which indicates the posterior border of the ulna; this marking is produced by the common extensor of the fingers, the extensor of the little finger and the ulnar carpal extensor and is especially evident when the wrist and fingers are extended forcibly. In line with this swelling and above it, pointing toward the external condyle, is a smaller longitudinal eminence due to the anconeus, which may be brought out by extension of the forearm. The prominent

swell on the radial side of the forearm represents the two radial carpal extensors and the brachio-radialis, while that on the ulnar side is due to the flexors of the forearm.

THE DORSAL SURFACE OF THE WRIST.—On the **ulnar side of the wrist,** the cuneiform bone is recognizable as a rounded protuberance below the ulnar styloid process; the interval between these projections corresponds to the inner extremity of the wrist-joint. The unciform is scarcely recognizable in the depression below the cuneiform. On the radial side of the wrist, in the depression below the lower extremity of the radius, the scaphoid bone may be felt upon adduction of the hand, and below and somewhat to the radial side of the scaphoid, the trapezium may be recognized, as well as its articulation with the metacarpal bone of the thumb. The other carpal bones are scarcely recognizable individually, the bones of the lower row being appreciated as a dorsally convex arch, apparently continuous with the metacarpal bones. On the dorsal aspect of the wrist an oblique ridge passing to the thumb indicates the tendon of the long extensor of the thumb, which bounds a depression, the **anatomical snuff=box,** between this tendon and the ridge on the lateral radial aspect of the wrist caused by the tendon of the metacarpal extensor of the thumb and that of the short extensor (Fig. 45). Deep pressure in this space close to the tendon of the long extensor of the thumb will disclose the tendons of the long and the short radial extensors of the wrist, made more evident by extension of the hand. Upon the ulnar side of the tendon of the long extensor of the thumb, will be found the tendon of the extensor of the index-finger and the tendons of the common extensor of the fingers, and well toward the ulnar side, the tendon of the extensor of the little finger; these are readily traced in their course over the dorsal surface of the hand. The tendon of the extensor carpi ulnaris may be felt as a tense band passing from the radial side of the styloid process of the ulna to the base of the fifth metacarpal bone.

THE DORSAL SURFACE OF THE HAND.—The shafts of the metacarpal bones and their distal heads are easily recognizable. The tendons of the fingers noted above as passing across the dorsal aspect of the wrist are traceable over the dorsum of the hand, especially when their muscles are in action (Fig. 45). The skin is notably thin and lax and the superficial veins are conspicuous. The knuckles are due chiefly to the distal extremity of the proximal bone in each case.

DISSECTION.

The skin-flap already dissected from the palmar surface of the forearm may be removed to expose the dorsal surface, or a longitudinal median incision may be made reflecting two flaps of skin, the forearm being prone upon the table or board.

The Superficial Fascia.—The looseness of the superficial fascia over the dorsum of the hand has been commented upon (page 119). Otherwise the fascia is worthy of note only because of its contents, the vessels and nerves. Over the olecranon process is a **bursa** which may be detected in the dissection of the superficial fascia by making a vertical incision and noting the escape through it of a small quantity of fluid.

Inflammation of this bursa, called "miner's elbow," may result from blows or other injury and may be attended with a great deal of swelling.

The **superficial veins** of the dorsal surface of the forearm and hand (Fig. 67) constitute a rather intricate plexus which may almost as well be studied upon the living subject as upon the cadaver. The largest trunks are the **radial** (antebrachial part of cephalic vein) and the **posterior ulnar** (a part of the antebrachial portion of the basilic) veins situated in the regions indicated by their names and these should be dissected. The other smaller branches are scarcely worthy of the time necessary for their dissection. The veins of the dorsum of the hand include a **plexus for each digit,** the veins of each plexus converging at the finger clefts to form the four **dorsal metacarpal veins,** but receiving first the **intercapitular** veins from the palm. The dorsal metacarpal vein of the first space is the **v. cephalica pollicis,** that of the fourth space, the **v. salvatella,** the former being the chief origin of the radial vein and the latter of the ulnar. In dissecting the two trunks indicated the dissector should be on the watch for cutaneous nerves along the radial and ulnar borders of the forearm respectively, as described in the next paragraph.

The **superficial nerves** of the dorsal surface of the forearm (Fig. 67) are the radial nerve on the radial side in the lower third, and the posterior division of the musculo-cutaneous as well as the lower external cutaneous branch of the musculo-spiral, which also should be looked for along the radial aspect of the forearm; while on the ulnar side, the posterior branch of the internal cutaneous and near the wrist the dorsal cutaneous branch of the ulnar should be looked for and traced.

The **radial nerve** (page 103) lies under the deep fascia at its first appearance on the dorsal surface but soon becomes superficial. Traced downward (Fig. 67) it is found to divide into an *internal* and an *external branch* which collectively supply the dorsal aspects of the thumb, the index-finger, the middle finger and the radial half of the ring finger in part, the distal extremities of these digits being supplied by the dorsal branches of the digital nerves from the median. The recognition of the radial nerve is usually easy. The main trunk should be freed by several strokes of the scalpel close to and parallel with the nerve and on each side of it, when it may be held up by the left little finger, the tension thus produced making the branches more evident, while the forceps, held in the left hand, catches up the connection tissue covering the

nerve that it may be more readily incised. Care is requisite in following the smaller filaments to avoid too great tension. The **dorsal cutaneous branch of the ulnar** reaches the dorsal surface at the lower extremity

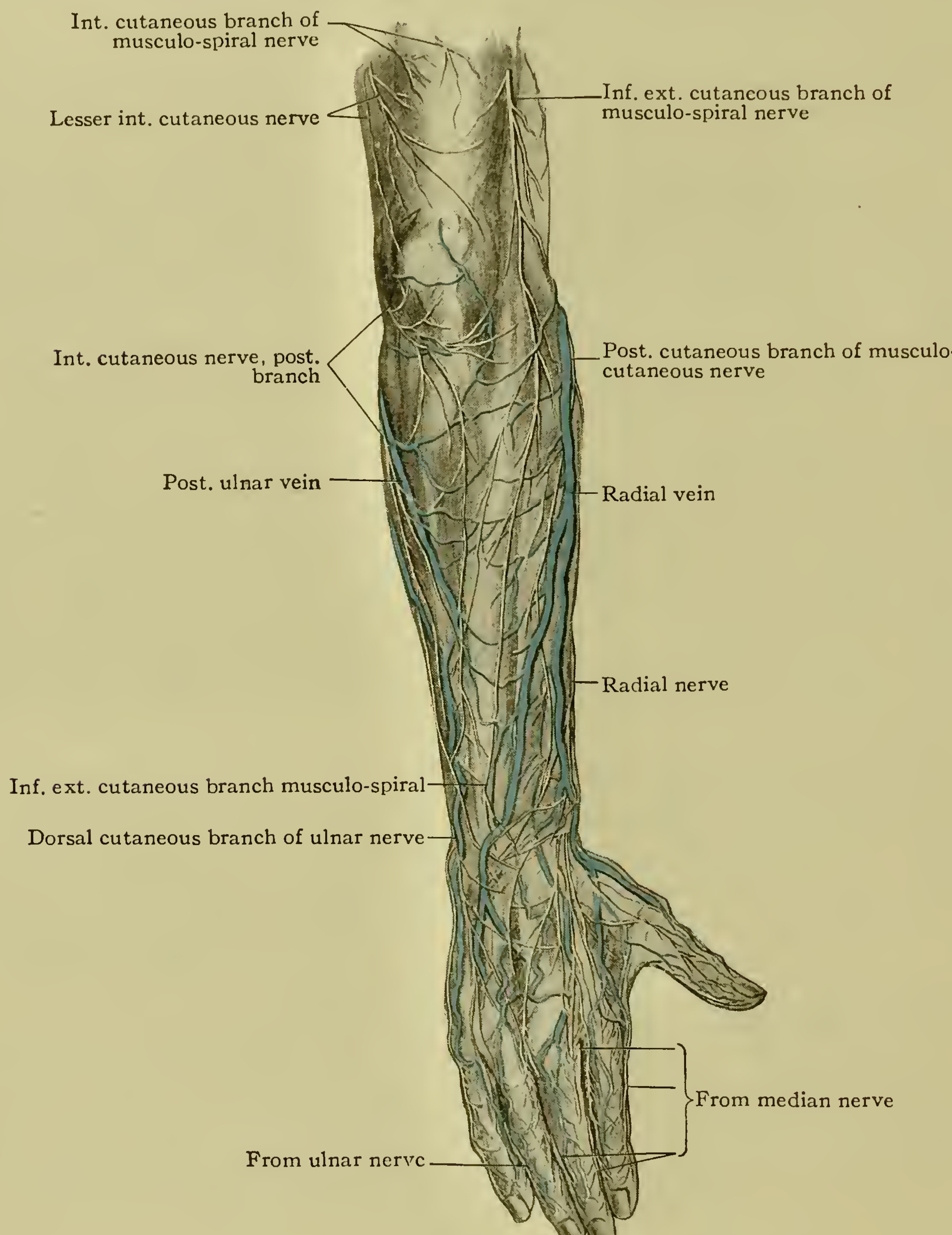

Fig. 67.—Superficial nerves and veins of dorsum of forearm and hand.

of the forearm and passes close to the ulnar border of the hand, dividing into a *digital* branch which again divides for the adjacent sides of the ring and little fingers, and a *second branch* for the ulnar side of the little

finger. The **dorsal division** of the musculo-cutaneous nerve and the **lower external cutaneous branch** of the musculo-spiral may vary in size and distribution, one being correspondingly larger when the other is smaller.

The remnants of the superficial fascia and the smaller veins may be removed to expose the deep fascia.

The looseness of the superficial fascia on the dorsum of the hand accounts for the readiness with which the tissues here swell in œdema or in inflammation of the part as well as for the engorgement of the superficial veins of the region when the hand is allowed to hang down or when there is constriction of the wrist or forearm.

The Deep Fascia.—The dorsal part of the antebrachial fascia is attached above to the bony prominences of the elbow and is continuous with the deep fascia of the arm. It is attached to the entire posterior border of the ulna and presents a thickening at the wrist in the form of a transverse band, the **posterior annular ligament,** ligamentum carpi dorsale (Fig. 68), for the binding down of the extensor tendons. The dorsal carpal ligament is attached externally to the radius and its styloid process and on the ulnar side to the pisiform and cuneiform bones. Two transverse incisions may be made through the deep fascia, one above and one below the annular ligament, that the latter may be left in place, when the remainder of the deep fascia may be removed by making a median vertical incision and dissecting toward either border of the forearm. In removing the deep fascia from the hand, care must be exercised not to injure the underlying tendons, which are plainly visible.

Before disturbing the muscles which are now exposed the student should note their position and the positions of their tendons, which latter have already been pointed out (page 136). An oblique muscular mass traceable by its upper extremity to the outer condyle of the humerus, consists of the superficial group of extensors, the extensor carpi ulnaris, the extensor communis digitorum, the extensor minimi digiti, and a muscle usually described as belonging to the radial group, the extensor carpi radialis brevior; all these having their origin by a common tendon from the external condyle. Upon the upper and inner side of this mass is the rather narrow anconeus muscle.

Anconeus (Fig. 68).—**Origin,** by a separate tendon from the external condyle; **insertion,** the upper fourth of the shaft of the ulna on its posterior aspect and the outer surface of the olecranon (Fig. 44); **nerve-supply,** the musculo-spiral nerve (seventh and eighth cervical); **action,** to aid in extension of the forearm. The surface of this muscle having been cleaned, it should be separated from the superficial extensors which lie upon its radial side, and should then be traced to its insertion upon the ulna and raised upon the handle of a scalpel or a director to show its form.

Extensor Communis Digitorum (Fig. 68).—**Origin,** by the common tendon from the external condyle and the adjacent intermuscular septa; **insertion,** by four tendons into the bases of the middle and distal phalanges of the four fingers; **nerve-supply,** the posterior interosseous

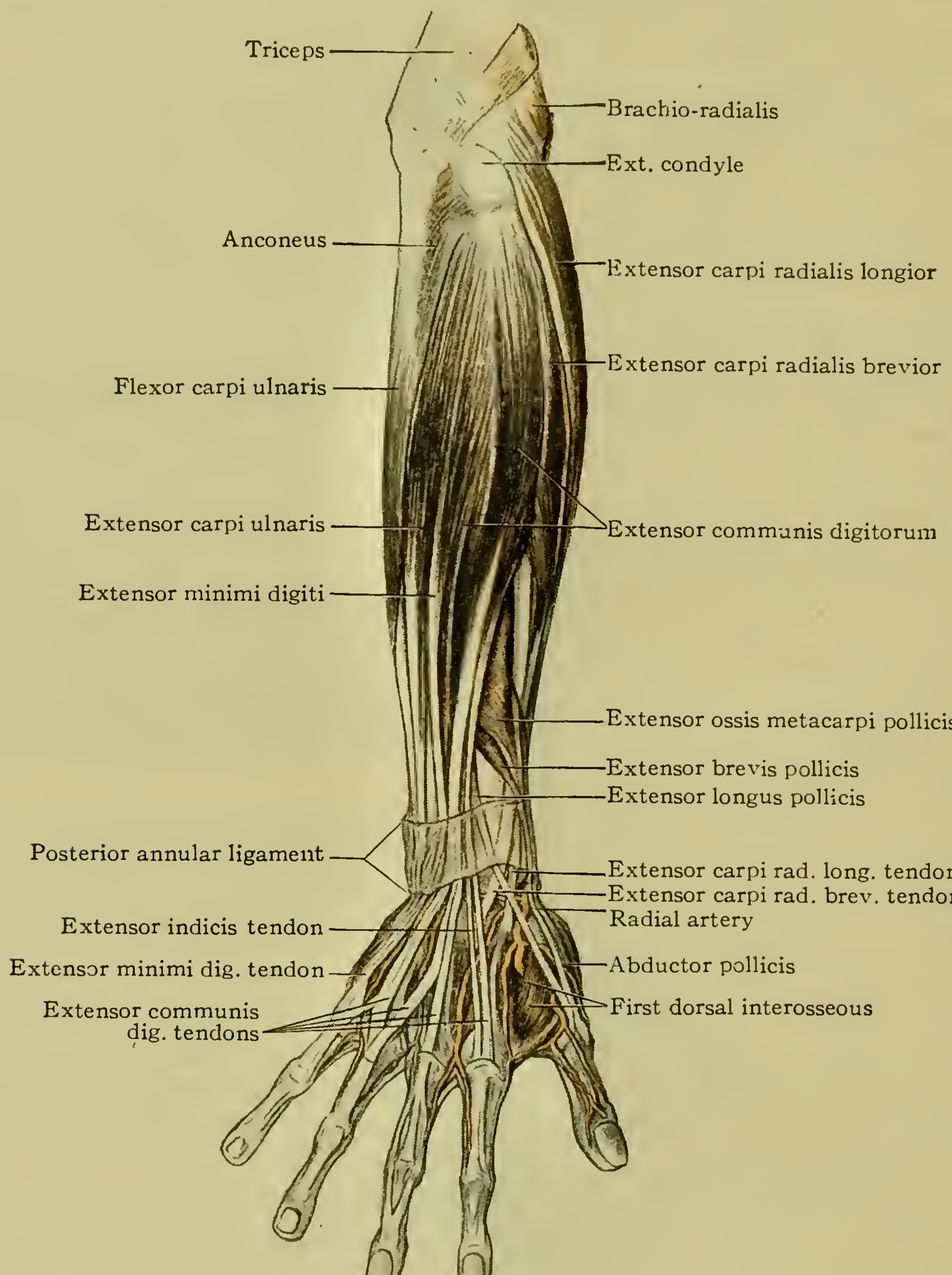

Fig. 68.—Superficial dissection of posterior surface of forearm and hand, showing muscles, vessels and nerves.

nerve (sixth, seventh and eighth cervical); **action,** the extension of the middle and distal phalanges and to aid in extension of the hand.

Separating the brachio-radialis and the two radial carpal extensors from this muscle, which lie upon its radial side, the close association

of the short radial carpal extensor will be noted. Upon the ulnar side it is very closely associated with the extensor of the little finger and the ulnar carpal extensor; the latter should be separated from the common extensor up to the external condyle. The extensor of the little finger is so closely associated with the common extensor as to appear a part of it. This may be separated for a part of its extent. The tendons of the common extensor, which begin a little below the middle of the forearm and are usually three in number, should now be followed under the annular ligament, a compartment under which they share with the extensor indicis tendon, to the hand, the tendons for the ring finger and little finger being one until the lower part of the hand is reached. The tendon for the little finger is accompanied by the special extensor tendon for that finger, as is the tendon for the index-finger accompanied by the special extensor of the index-finger. The tendons near the distal portion of the hand are connected with each other by transverse or oblique bands, the connecting band between the index-finger tendon and that of the middle finger being frequently absent, while the bands between the ring and little fingers and the ring and middle fingers are well marked. Each extensor tendon at the metacarpo-phalangeal joint spreads out into an aponeurosis which constitutes the posterior ligament of that joint, and a little in advance of the joint receives the insertions of the interossei and lumbricales. The tendon then divides into three slips, the middle one of which is inserted upon the base of the second phalanx, the two lateral slips reuniting to be inserted into the base of the distal phalanx (Fig. 70). These tendons furnish the posterior ligaments of the interphalangeal joints as well as those of the metacarpo-phalangeal joints (Fig. 73).

The connecting slips between the tendons of the third, fourth and fifth digits hamper greatly the independent extension of the fourth finger while the third and fifth are flexed, a condition which is of considerable inconvenience to piano-players; hence the division of these bands as proposed and practised by Forbes.

Extensor Minimi Digiti (Fig. 68).—**Origin,** by the common tendon from the outer condyle of the humerus and the deep fascia; **insertion,** the second and third phalanges of the little finger, in connection with the fourth tendon of the common extensor; **nerve-supply,** the posterior interosseous nerve; **action,** extension of the little finger.

This long, slender muscle, as already indicated, is very closely associated with the common extensor, but its tendon passes under the posterior annular ligament more to the ulnar side of the wrist than those of the common extensor. Mention has already been made of the association of this tendon with the fourth tendon of the common extensor.

Extensor Carpi Ulnaris (Fig. 68).—**Origin,** by the common tendon from the outer condyle and by the aponeurosis common to it

and the ulnar carpal flexor and the flexor profundus digitorum from the posterior border of the ulna; **insertion,** the base of the fifth metacarpal bone; **nerve=supply,** the posterior interosseous nerve; **action,** extension of the wrist.

The tendon of this muscle should be followed under the posterior annular ligament close to the ulnar border of the wrist to the base of the fifth metacarpal bone.

Pulling the extensor carpi ulnaris toward the ulnar side of the forearm and the other superficial extensors toward the radial side, the deep extensors will be exposed; these are the three extensors of the thumb, the special extensor of the index-finger, and the supinator brevis (Fig. 69).

Supinator (supinator radii brevis) (Fig. 44).—**Origin,** the outer humeral condyle, the orbicular ligament and the triangular area on the ulna below its lesser sigmoid cavity; **insertion,** the oblique line of the radius and the shaft of the bone above the oblique line on the anterior, posterior and outer aspects; **nerve=supply,** the posterior interosseous (sixth cervical); **action,** supination of the forearm.

The surface of this muscle will be seen to be somewhat aponeurotic, and emerging from the dorsal surface of the muscle is the posterior interosseous nerve, which should be identified and isolated at once in order to preserve it from injury. Placing the forearm in the supine position, the anterior part of the muscle should be examined and the entrance of the posterior interosseous nerve into this part of the muscle noted (Fig. 55), the nerve passing between the superficial and deep planes of the muscle.

The Posterior Interosseous Nerve and Artery.—Near the ulnar border of the supinator brevis, the **posterior interosseous artery,** a branch of the common interosseous of the ulnar, emerges upon the dorsal aspect of the forearm, having passed through the interosseous space above the upper border of the interosseous membrane and below the oblique ligament. Its **interosseous recurrent branch** should be traced upward to the region of the outer condyle, where it ramifies and inosculates with the deep branch of the superior profunda and the anastomotica magna. The posterior interosseous artery passes down the forearm upon the deep group of muscles (Fig. 69), and should now be traced in its course downward to its point of connection at the lower extremity of the forearm with the posterior branch of the anterior interosseous artery which has pierced the interosseous membrane, and in its further course to communicate with the posterior carpal arch; the artery gives off muscular branches in its course.

The **posterior interosseous nerve,** a terminal branch of the musculospiral (page 99), piercing the supinator brevis muscle upon the outer side of the radius as indicated above, also passes down the forearm

between the superficial and deep group of extensors, supplying **branches** to all of the extensors as its goes, except those supplied by the trunk of the musculo-spiral, *i.e.*, the anconeus, the brachio-radialis and the two radial carpal extensors. At the posterior aspect of the wrist

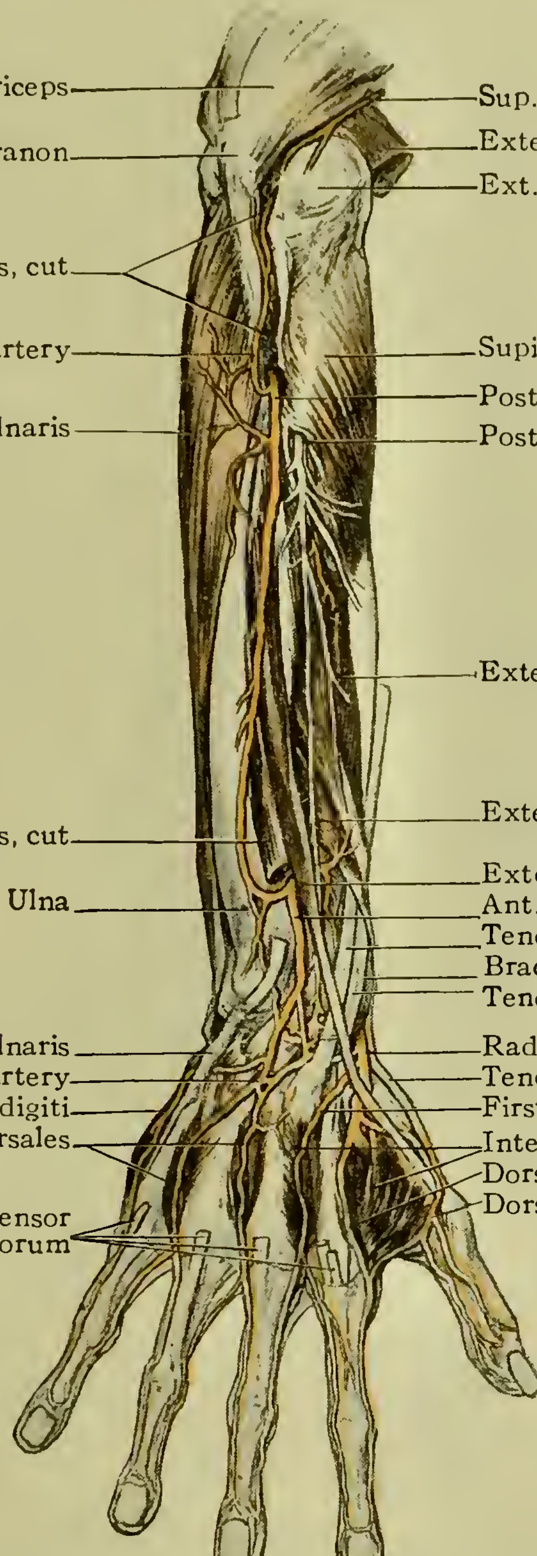

Fig. 69.—Deep dissection of posterior surface of forearm and hand.

the nerve presents an enlargement, commonly called a ganglion, and branches from this pass to the wrist-joint.

Extensor Ossis Metacarpi Pollicis (m. abductor pollicis longus) (Fig. 69). — **Origin,** the posterior surfaces of the radius and ulna at approximately their middle thirds and the corresponding por-

tion of the interosseous membrane; **insertion,** the radial side of the base of the metacarpal bone of the thumb; **nerve-supply,** the posterior interosseous nerve (sixth, seventh and eighth cervical); **action,** extension of the metacarpal bone of the thumb.

The tendon, traced downward, is found closely associated with the tendon of the short extensor of the thumb,—the muscles themselves often being partially united,—crosses the radial carpal extensor tendons, and, passing through the groove on the outer side of the lower extremity of the radius, crosses the radial artery before reaching its insertion, and constitutes the outer boundary of the "snuff-box." Beyond the groove of the radius the dissector should elevate the tendon carefully so as to avoid injury to the underlying radial artery.

Extensor Brevis Pollicis (extensor primi internodii pollicis) (Fig. 69). — **Origin,** the dorsal aspect of the shaft of the radius below the origin of the metacarpal extensor and the interosseous membrane; **insertion,** the base of the proximal phalanx of the thumb; **nerve-supply,** the posterior interosseous nerve (from the sixth, seventh and eighth cervical); **action,** extension of the proximal phalanx of the thumb.

This muscle is closely associated with the preceding, though smaller, and its tendon, as already shown, passes along with the tendon of the preceding muscle, helping to form the outer boundary of the "snuff-box." Both this tendon and that of the preceding muscle should be raised carefully to avoid not only injury to the radial artery but to any of its branches.

Extensor Longus Pollicis (extensor secundi internodii pollicis) (Fig. 69).—**Origin,** the dorsal aspect of the ulna below the origin of the metacarpal extensor and from the interosseous membrane; **insertion,** the proximal end of the distal phalanx of the thumb; **nerve-supply,** the posterior interosseous nerve (from the sixth, seventh and eighth cervical); **action,** extension of the distal phalanx of the thumb.

The tendon should be followed under the annular ligament obliquely across from the dorsal aspect of the wrist to the metacarpo-phalangeal joint of the thumb and along the mid-line of the first phalanx to its destination. This tendon forms the inner boundary of the "snuff-box." The radial artery passing under the tendon should be avoided in following the latter.

Extensor Indicis (extensor indicis proprius) (Fig. 69).—**Origin,** the shaft of the ulna on its dorsal aspect near the lower extremity, below the origin of the long extensor of the thumb; **insertion,** the second and third phalanges of the index-finger in common with the tendon of the common extensor; **nerve-supply,** the posterior interosseous nerve (seventh and eighth cervical); **action,** extension of the index-finger.

The Radial Artery.—The **carpal portion** of the radial artery (p. 110) leaves the palmar aspect of the forearm by passing under the tendons

of the metacarpal extensor and the short extensor of the thumb, crossing the external lateral ligament, and enters the anatomical "snuff-box," lying here upon the trapezium and leaving the "snuff-box" by passing under the tendon of the long extensor of the thumb. It now leaves

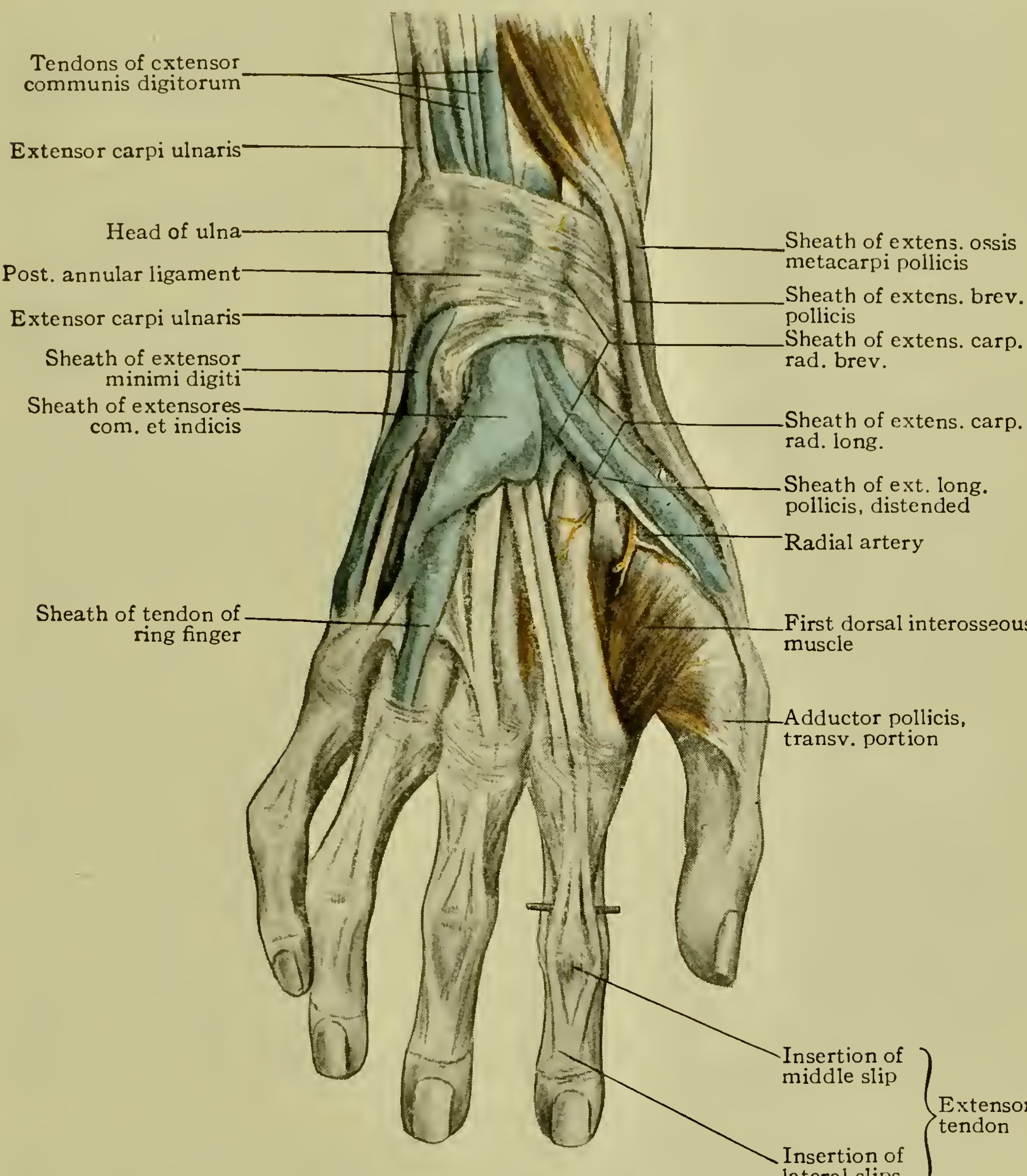

FIG. 70.—Dissection of dorsal surface of hand, showing sheaths of extensor tendons injected.

the dorsum of the hand by passing between the two heads of the first dorsal interosseous muscle or abductor indicis near the proximal extremities of the metacarpal bones, and enters the palm of the hand (**palmar portion** of the artery) where it forms the deep palmar arch as already shown (page 131).

10

The Branches of the Carpal Portion of the Radial Artery.—These are the *posterior radial carpal*, the *dorsalis pollicis* and the *dorsalis indicis*. The **posterior radial carpal artery,** the first branch, passes across the posterior aspect of the wrist under the tendons toward the ulnar side, to unite with the posterior carpal branch of the ulnar to form the **posterior carpal arch.** In dissecting this posterior carpal arch, connections with the termination of the anterior and posterior interosseous arteries will be found (Fig. 69); *branches* of the posterior carpal arch, the **dorsal interosseous arteries** for the second, third and fourth interosseous spaces, pass downward along these spaces to the finger clefts to anastomose with the digital branches of the superficial arch. The proximal parts of the dorsal interosseous arteries receive the perforating branches from the deep palmar arch.

Thus the deep palmar arch is connected with the posterior carpal arch and the latter with the anterior and posterior interosseous arteries, which are also connected with the anterior carpal arch (page 133).

The **dorsalis pollicis,** a branch passing to the dorsal surface of the thumb, divides into two branches (or two branches may arise from the radial separately), each branch passing along a border of the dorsal aspect of the thumb. A little farther along the dissector will come upon the **dorsalis indicis,** which runs along the radial aspect of the dorsum of the index-finger.

Interossei Dorsales (Fig. 69).—The dorsal interosseous muscles are four in number, lying between the metacarpal bones and projecting to some extent into the palm (Fig. 66). **Origin,** in each case, the proximal halves of the two metacarpal bones between which the muscle lies; **insertions,** the first and second into the radial sides of the first phalanges of the index- and middle fingers; the third and fourth into the ulnar sides of the first phalanges of the third and fourth fingers; and all of them into the aponeuroses of the extensor tendons of the corresponding fingers; **nerve-supply,** the ulnar nerve (eighth cervical and first thoracic); **action,** abduction of the index-, middle and ring fingers from the middle line of the middle finger and to assist in flexion of the proximal and extension of the other phalanges of those fingers to which they pertain.

The first dorsal interosseous muscle or abductor indicis should now be cleaned and its double origin from the first and second metacarpal bones demonstrated, as well as the interval in the proximal part of the muscle through which the radial artery passes. In relation with the palmar surface of this muscle is the transverse adductor of the thumb. Separating these two muscles from each other, the radialis indicis and the princeps pollicis branches of the palmar portion of the radial artery should be found as well as the radial itself; these have already been encountered in the dissection of the palm (p. 133).

Let the dissector now examine and study the various structures which he has worked out, taking up each in turn and following it to its termination. For example, beginning with the axillary artery, and noting its course, extent, parts, branches and relations, let him follow the brachial artery in the same way and then the radial and the ulnar. Each of the large nerve-trunks should be treated in the same way, as should also the muscles. After the completion of this general survey, let him proceed to the dissection of the joints of the upper limb.

THE ARTICULATIONS OF THE UPPER LIMB.

The shoulder-joint, the description of which will be found at p. 61, if not already dissected, should be worked out at this time; after its completion, the upper limb may be separated from the trunk in the manner directed at p. 65.

The Elbow-Joint.—The **articular surfaces** involved in this modified **ginglymus** joint are the trochlea of the humerus articulating with the greater sigmoid cavity of the ulna and the capitellum of the humerus with the superior surface of the head of the radius. The **ligaments** are so blended as to form a capsule, which presents definitely localized thickenings in the form of bands: The **anterior ligament** (Fig. 72), attached above to the upper margins of the coronoid and radial fossæ and below to the coronoid process of the ulna and the orbicular ligament, presents a well-marked superficial band of obliquely directed fibres passing from the front of the inner condyle to the orbicular ligament. The **posterior ligament** is attached above to the upper and lateral margins of the olecranon fossa and below to the olecranon process. The **internal lateral ligament** (ligamentum collaterale ulnare), consisting of three diverging fasciculi, is attached by its apex to the inner epicondyle, the *posterior band* passing to the upper part of the inner margin of the olecranon, the *anterior* to the inner side of the coronoid process and the *middle*, deeper band to the inner margin of the greater sigmoid cavity. The **external lateral ligament** (ligamentum collaterale radiale) is attached above to the external epicondyle and below to the ulna and the orbicular ligament. The **synovial membrane** is referred to on p. 150. **Nerve-supply,** the ulnar (Fig. 71), the musculo-spiral (filaments from its trunk arising above the outer condyle and from its ulnar collateral branch), the musculo-cutaneous and the median, the articular branches of the latter passing the inner border of the brachialis anticus to reach the front of the capsule; **blood-supply,** from the vessels which ramify about the joint (see p. 149).

To expose the elbow-joint satisfactorily, the adjacent and overlying muscular structures must be removed. In doing this it is desirable to work out more fully the vessels and nerves in relation with the joint.

The radial carpal extensors and the brachio-radialis are to be detached from the outer condyle and condylar ridge, the dissector exercising care to avoid mutilating the radial recurrent artery and the anterior branch of the superior profunda in the region of the front of the outer

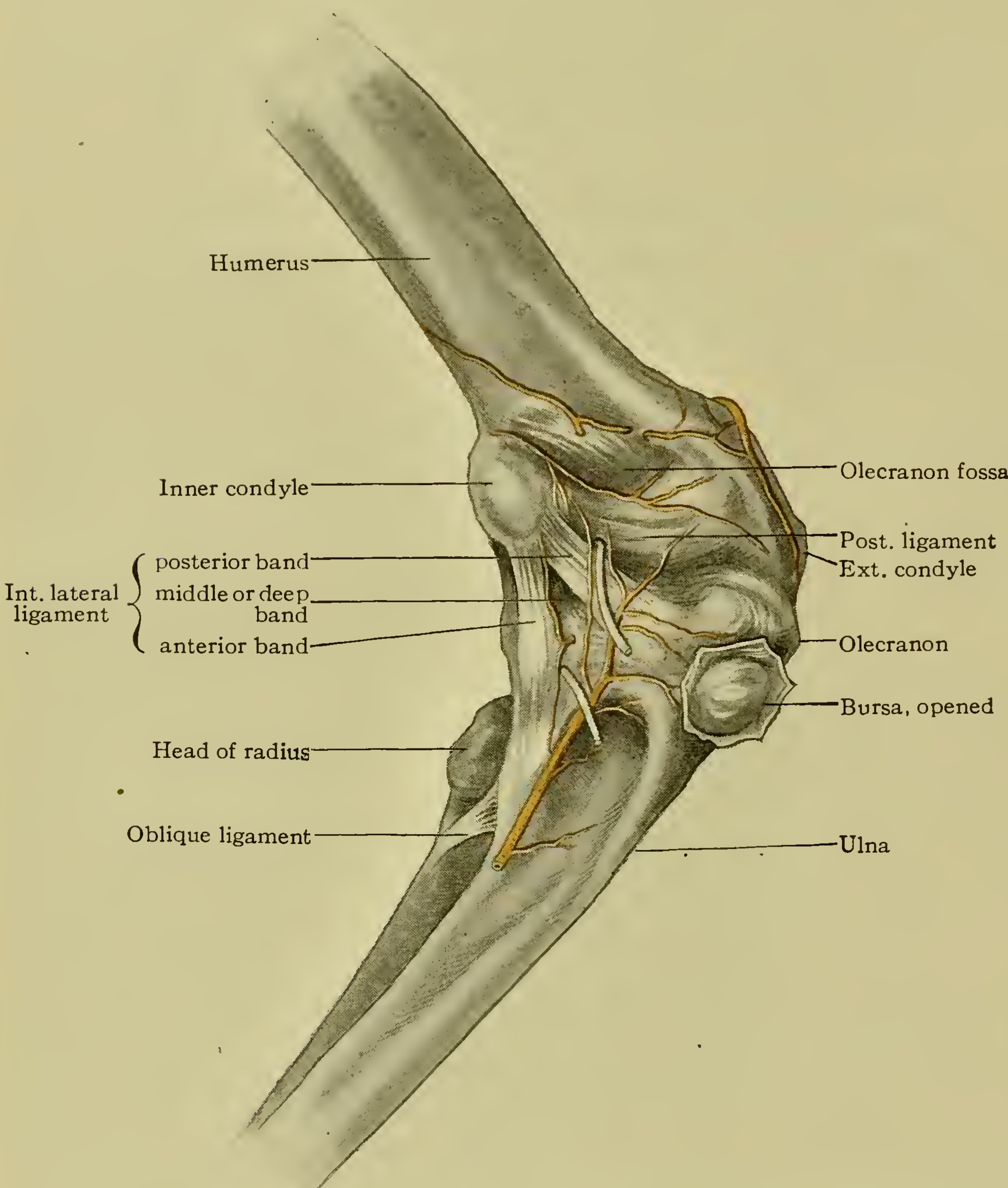

FIG. 71—Dissection of right elbow-joint, postero-internal view. The nerves seen entering the joint are the articular branches of the ulnar nerve. The posterior ulnar recurrent artery is shown passing upward; the smaller vessels are branches of the anastomotica magna and the inferior and superior profunda.

condyle, as well as the articular filaments of the musculo-spiral nerve. The removal of the common tendon of origin of the superficial flexors, or so much of it as may remain, from the inner condyle is to be effected with like precaution against disturbance of the anterior ulnar recurrent

artery and the anterior branches of the inferior profunda and anastomotica magna. Turning the limb over, the superficial extensors and the anconeus should be detached from the outer condyle with due regard for the interosseous recurrent artery and the posterior branch of the superior profunda, and the tendon of the triceps should be divided close to its insertion upon the olecranon.

The **vascular anastomoses about the elbow=joint** may now be studied with advantage. To summarize, the vessels concerned are, *in front of the outer condyle*, the radial recurrent branch of the radial from below and the anterior branch of the superior profunda of the brachial from above (Fig. 56); *behind the outer condyle*, the interosseous recurrent of the common interosseous of the ulnar from below inosculating with the posterior branch of the superior profunda and a branch of the anastomotica magna from above; *in front of the inner condyle*, the anterior ulnar recurrent ascending under the superficial flexors to connect with the inferior profunda and anastomotica magna; *behind the inner condyle*, the posterior ulnar recurrent, passing through the interval between the inner condyle and the olecranon in company with the ulnar nerve and giving off here *articular branches* (Fig. 71), to anastomose with the inferior profunda and anastomotica magna of the brachial.

The tendon of the biceps should now be divided within an inch of the bicipital tuberosity, the brachialis anticus cut transversely a few inches above the joint, and the distal portion of the muscle should be elevated from the front of the joint and be reflected or completely detached from the coronoid process, the dissector identifying the articular branches of the median nerve as they pass by the inner border of the muscle to reach the capsule.

The **anterior ligament** (Fig. 72) must now be cleaned, its attachment noted (p. 147) and the nerve filaments and vessels which perforate it demonstrated. The **posterior ligament** (Fig. 71) is to be similarly treated. The **internal lateral ligament** is best displayed by flexing the forearm, which brings out particularly well the posterior fasciculus. The middle fasciculus will be noted as lying upon a deeper plane than the anterior and posterior bands. The relation of the ulnar nerve, with its articular branches, and the posterior ulnar recurrent artery to this ligament (Fig. 71) has been referred to above. The **external lateral ligament** (Fig. 72) upon being completely denuded—the forearm being alternately flexed and extended to facilitate this work—is seen to consist of several bands which diverge as they pass downward from the external condyle, blending to an important extent with the orbicular ligament (Fig. 72). It is well to cut the anterior band, the tension of which is demonstrated by the consequent springing away of the head of the radius from the capitellum. If the inner edge of the incised capsule be raised, the coronoid fossa of the humerus is exposed, as well

as the trochlea and the greater sigmoid cavity of the ulna. A probe passed through the opening and directed downward between the margin of the head of the radius and the lesser sigmoid cavity of the ulna will demonstrate the continuity of the cavity of the elbow-joint with

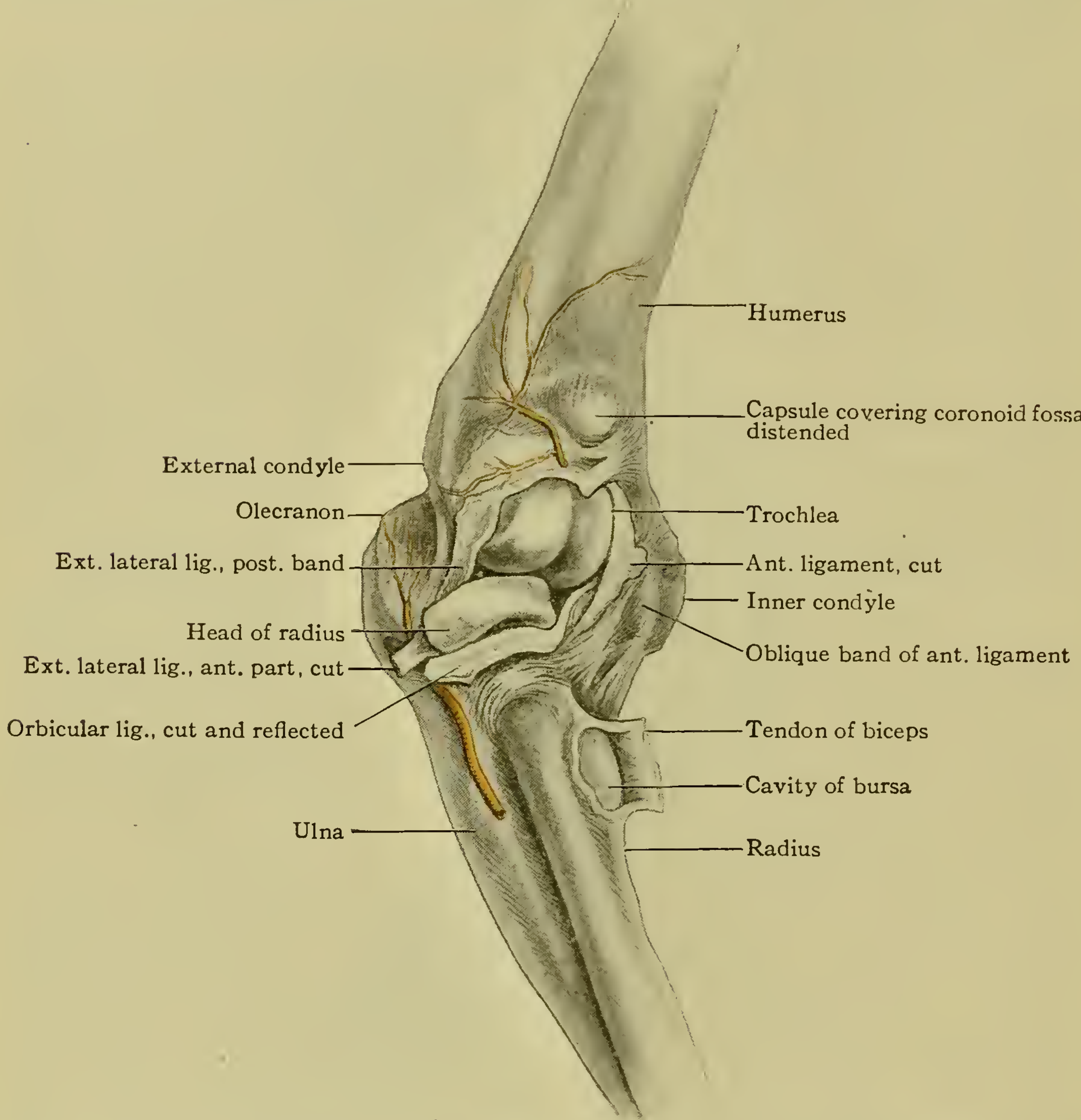

FIG. 72—Dissection of right elbow-joint, antero-external view. The interosseous recurrent artery is seen passing upward. Above are branches of the superior profunda and radial recurrent.

that of the superior radio-ulnar articulation, the **synovial** membrane of the former joint being therefore continuous with that of the latter.

If the form of the articulating surfaces of the joint be examined, it will be seen that they are so adapted to each other as to give greater security to the articulation than would be conferred by the ligaments alone. Dislocations of the elbow-joint include displacement of both radius and ulna in four directions—*backward*, *forward*, *outward* and *inward* in this order of frequency—and luxation of the ulna alone in the backward direction, the radius in such case being prevented from following the ulna

by contact of the upper surface of its head with the capitellum. The radius may also be dislocated alone. Mention has been made of the diagnostic importance of the relation of the olecranon to the condyles in the recognition of these displacements (p. 95). The free vascularity of the joint renders unreduced luxations "old" at a comparatively early date.

The diseases of the elbow-joint include *synovitis* and *arthritis*, which latter may be simple or tuberculous. In effusion into the joint, the swelling is first evident posteriorly on either side of the triceps tendon, because of the relative thinness and laxity of the posterior ligament and of its more superficial situation.

The Radio-Ulnar Articulations.—The muscles of the forearm must now be removed to completely expose the shafts of the bones and the interosseous membrane. The vessels in relation with the membrane should be allowed to remain. Let the dissector now alternately pronate and supinate the hand and note the varying relations between the shafts of the bones which are thus brought about, as well as certain differences in the anterior and posterior radio-ulnar ligaments. Thus, it is apparent that the shafts of the bones are most nearly parallel and are farthest apart, and consequently the interosseous membrane is most tense, when the forearm is midway between pronation and supination, *i.e.*, when the thumb points upward. One may note, too, that in full supination, the lower extremity of the radius is on a plane somewhat above—when the forearm is in the horizontal plane—the head of the ulna, while in full pronation the head of the ulna projects dorsally. The axis of rotation of the radius is seen to correspond with a line passing through the head of the radius, the head of the ulna and the ring finger (Treves). One may demonstrate, too, by laying the forearm supine upon a board and placing the inner side of the distal end of the ulna against a push-pin or nail driven into the board, a form of rotation of the radius around the ulna without change of position by the latter bone; the same sort of rotation may be illustrated in the living subject by steadying one's right elbow against the side of the back of the chair as one sits before a table, placing the right wrist supine upon the table's edge, and then bringing the forearm into the prone position while the left thumb and index-finger, aided by voluntary effort, seek to prevent movement of the ulna. Ordinarily, however, the head of the ulna moves outward somewhat as the radius rotates inward. This is well shown by sitting in the position just indicated but placing the tip of the left thumb on the table on the ulnar side of the right wrist and the index-finger on its radial side. Alternate pronation and supination will demonstrate the participation of both bones in these movements. If, now, the reader will grasp his right forearm just below the elbow, the forearm being in the supine position, placing the tips of the fingers of the left hand immediately to the outer side of the posterior border of the ulna so that the tip of the little finger rests between the olecranon and the outer condyle, while the left thumb rests upon the anterior surface of

the forearm, the act of supination will enable him to recognize the two chief agents that produce this act. Under the tips of his fingers he will note the contraction of the anconeus to bring about the necessary outward movement of the distal end of the ulna, and under his thumb he will perceive the pronator radii teres in action as it rotates the radius inward.

The Superior Radio-Ulnar Articulation.—The superior or proximal radio-ulnar articulation (Fig. 72), which is of the **trochoid** variety, occurs between the periphery of the head of the radius and the lesser sigmoid cavity of the ulna. The **ligament** is the *orbicular ligament*, a strong band which is attached to the anterior and posterior margins of the lesser sigmoid cavity and closely embraces the head and neck of the radius, being attached also to the inner side of its neck but being separated elsewhere from the bone by the synovial membrane. The connection of this ligament with the external lateral ligament of the elbow-joint has been noted above, as well as the continuity of the **synovial membrane** with that of the elbow-joint.

The **middle radio-ulnar articulation** is merely an association between the shafts of the bones by the interosseous membrane and the oblique ligament. The **oblique ligament** (chorda obliqua) is a band which passes from the tubercle of the ulna downward and outward to the upper end of the oblique line of the radius (Fig. 71). The **interosseous membrane** (membrana interossea interbrachii), connecting the adjacent interosseous borders of the radius and ulna, consists chiefly of fibres which pass downward and inward from the radius to the ulna, but includes a few bands passing downward and outward. The relations of the anterior interosseous nerve and artery and of the deep muscles of the forearm to this membrane have been indicated.

The Inferior Radio-Ulnar Articulation.—This **trochoid** or **pivot-joint,** formed by the apposition of the sigmoid cavity of the radius and the lateral articular surface of the head of the ulna, includes as its **ligaments, anterior** and **posterior** bands forming a capsule, and the **fibro-cartilage** or **discus articularis.** The discus articularis (Fig. 74) is triangular in shape, quite flexible, and separates the inferior articular surface of the head of the ulna from the cuneiform bone. Its apex, directed inward, is attached by a short band to the depression between the styloid process of the ulna and the head of that bone, while its base is attached to the lower margin of the sigmoid cavity of the radius, and its anterior and posterior borders are connected with the ulna and the ligaments of the wrist-joint. Both the upper and the lower surfaces are concave, the thinned-out central portion being occasionally perforated. The **synovial membrane** of this joint, the **membrana sacciformis,** lines the horizontal portion of the joint-cavity between the ulna and the cartilage as well as the space between the articular surfaces of the two bones.

With the hand in the position of pronation, let the dissector incise the posterior ligament of this joint (Fig. 73) and the synovial sac by a vertical cut, following this by a transverse incision close to the lower extremity of the ulna, the knife, in the latter case, entering between the ulna and the discus. Further and more satisfactory examination

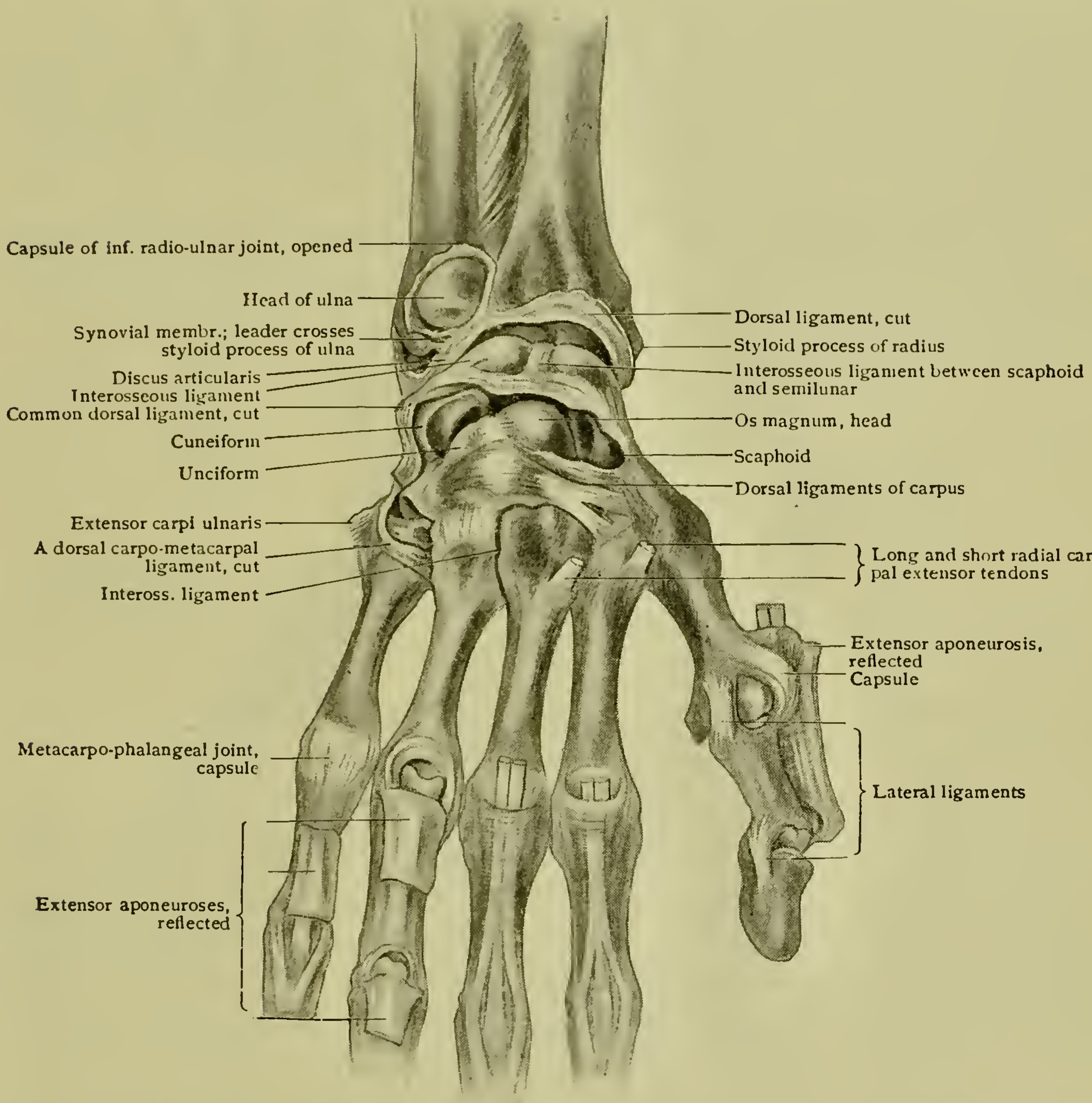

FIG. 73.—Dissection of the inferior radio-ulnar, the radio-carpal, the intercarpal, the carpo-metacarpal, the metacarpo-phalangeal and the interphalangeal articulations, dorsal view.

of the discus may be made during the dissection of the wrist-joint.

THE WRIST-JOINT (articulatio radiocarpea).—The **articular surfaces** involved in the radio-carpal joint (Fig. 73), which is of the **condyloid** type, are the lower surface of the radius and that of the discus articularis, constituting the receiving cavity, and the upper surfaces of the scaphoid, semilunar and cuneiform bones forming the condyle or meniscus.

The **ligaments,** which are merely localized thickenings of a *capsule*, are the **internal lateral** (l. collaterale carpi ulnare), a rounded band attached above to the ulnar styloid process and below, where it is split, to the inner side of the cuneiform bone and to the pisiform bone; the **external lateral** (l. collaterale carpi radiale), passing from the radial styloid process to the outer side of the scaphoid and to a slight extent to the trapezium; the **anterior ligament** (l. radiocarpeum volare), broad and membranous, connecting the lower margins of the radius and ulna with the palmar surfaces of the first row of carpal bones except the pisiform; the **posterior ligament** (l. radiocarpeum dorsale), attached above to the lower edge of the dorsal aspect of the radius and below to the dorsal surfaces of the scaphoid, semilunar and cuneiform bones.

The **blood-supply** is effected by the anterior and posterior carpal branches of the radial and ulnar arteries, the anterior and posterior interosseous arteries and the deep palmar arch (Figs. 69 and 65).

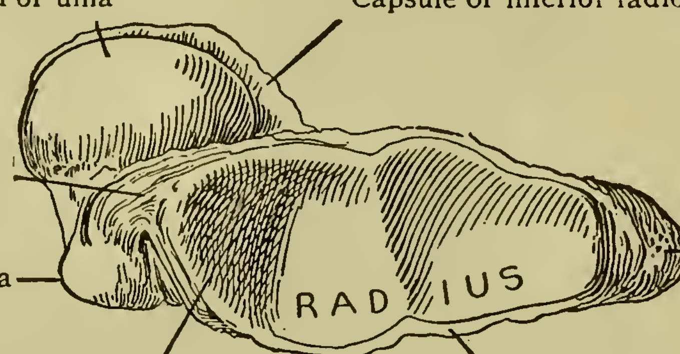

Fig. 74.—Lower end of right radius in pronation.

The **nerve-supply** is from the ulnar (Fig. 75), the posterior interosseous (Fig. 69), and in some cases, at least, the median (Fig. 75).

The **relations of tendons** to this joint, those of the flexor profundus digitorum and the flexor longus pollicis, and less intimately those of the flexor sublimis digitorum and flexores carpi ulnaris and radialis in front, and of the extensor tendons of the wrist and digits dorsally and laterally are to be noted in denuding the capsule.

The dissector will appreciate, in his efforts to recognize and identify the ligaments of this joint, that they blend with the ligaments of the intercarpal articulations to no inconsiderable degree. Note should be made of the obliquity of certain bands in the anterior and posterior ligaments and especially of that rounded fasciculus of the former which passes from the front of the ulna to the semilunar and cuneiform bones, as well as of the general laxness of the capsule. After studying the **movements** of the joint, flexion, extension, adduction, abduction and circumduction, and isolating the entering nerves and vessels, the capsule may be incised, preferably by a transverse cut on the dorsal aspect, a line

or two below the radius, that the articular surfaces may be studied. This incision well displays these surfaces, that of the radius showing the division into the two facets for the scaphoid and semilunar respectively, the surfaces of the latter bones appearing practically as a unit forming the "condyle" but their separate identity being plainly indicated by a

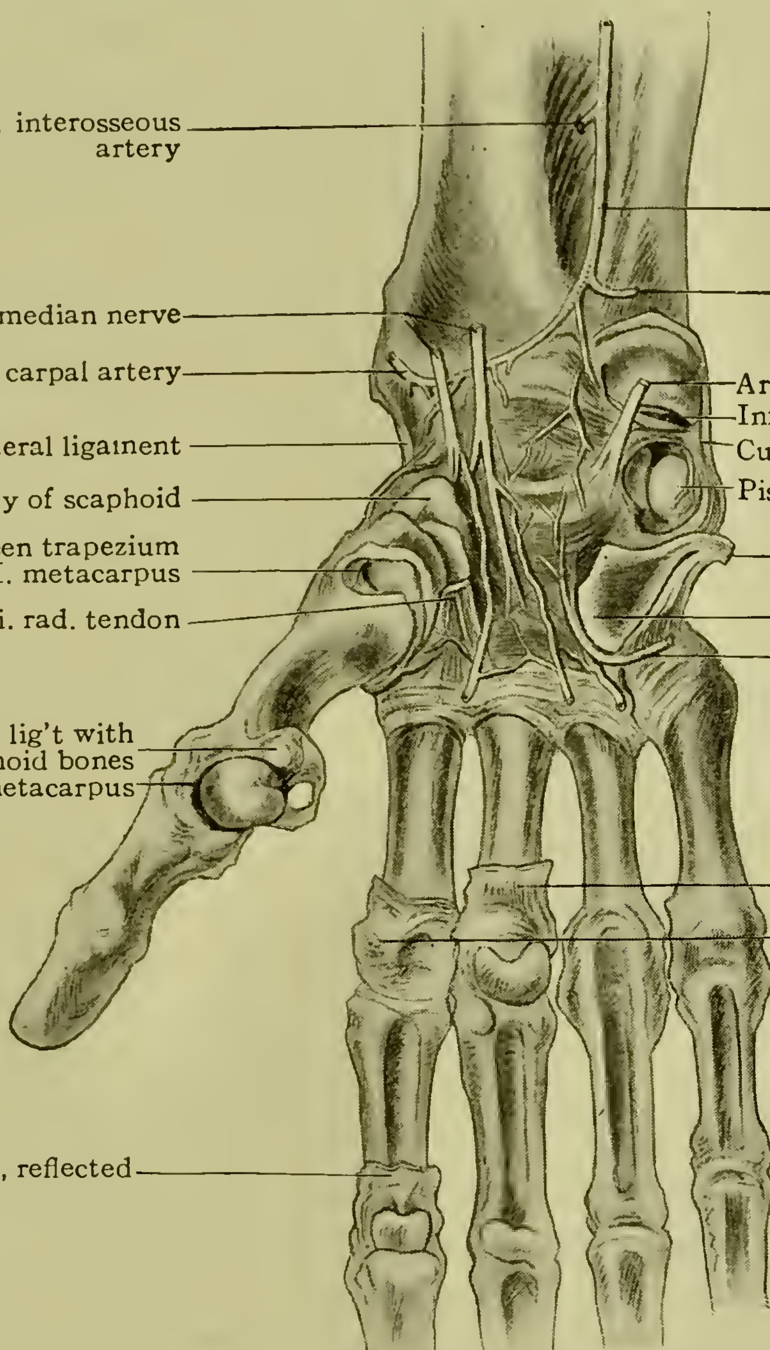

FIG. 75.—Dissection of the inferior radio-ulnar, the radio-carpal, the intercarpal, the carpo-metacarpal, the metacarpo-phalangeal and the interphalangeal articulations, volar view.

rounded antero-posterior ridge, the **interosseous ligament,** which connects these two bones (Fig. 73) and helps to separate the cavity of the wrist-joint from the intercarpal joints. A similar incision may be made on the anterior surface of the joint, supplemented by division of the internal lateral ligament in order to expose more fully the articular disk or triangular cartilage, the attachments of which latter (p. 152) should now be noted.

From this study of the wrist-joint it is apparent that neither the form of the articulated surfaces nor the strength of the ligaments confers a great degree of security upon the joint, and that its stability must depend largely therefore upon the protection afforded by the related tendons and their fibrous sheaths. Even with this safeguard it might be expected, considering the degree of exposure of the joint to injury, that **luxations** here would be of more frequent occurrence than they are. As a matter of fact, they are comparatively infrequent. They comprise the *backward* dislocation, which is much the most common variety; the *forward* and the quite rare *inward* and *outward* luxations.

The **diseases** to which the joint is liable are *synovitis*, the effusion attending which is first and most apparent on the posterior surface because of the relative thinness of the posterior ligament and its closer proximity to the surface; and *arthritis*, which may be of tuberculous, rheumatic or gonorrhœal type.

The Carpal Joints (articulatio intercarpea).—These joints, which are chiefly **arthrodial** in type, include the articulations of the proximal row with the second row of bones and of the individual bones with each other.

The Joints of the Proximal Row of Carpal Bones.—The **ligaments** concerned are *palmar* and *dorsal* bands which connect the palmar and dorsal surfaces respectively of the scaphoid and semilunar and the semilunar and cuneiform (Figs. 73 and 75), a *capsular ligament* connecting the pisiform with the cuneiform and *two interosseous ligaments*, one between the scaphoid and semilunar and one between the semilunar and the cuneiform (Fig. 73).

To expose the dorsal and palmar ligaments, the anterior and posterior ligaments of the wrist-joint must be removed from their attachments to the carpal bones, the association between the two sets of ligaments being very intimate. The **interosseous ligaments** (Fig. 73), on a level with the proximal surfaces of the bones to which they pertain, help to form the cavity of the wrist-joint and to separate it from the cavities of the carpal joints. After noting the **piso-uncinate** and **piso-metacarpal** or **palmar ligaments,** which connect the pisiform bone with the uncinate process of the unciform and the base of the fifth metacarpal bone respectively, the capsule of the piso-cuneiform joint may be opened. Its synovial sac is strictly isolated.

Articulations Between the Two Rows of Carpal Bones, the Mid-Carpal Joint.—The **ligaments** concerned are *anterior* or *volar* and *posterior*, and *internal* and *external lateral ligaments* connecting the contiguous surfaces of the bones involved in the regions corresponding to their names. Let the dissector incise the dorsal ligament (Fig. 73) and note that the trapezium and trapezoid articulate with the scaphoid, the unciform with the cuneiform, while the head of the os magnum (Fig. 73) is received into a socket-like depression formed by the scaphoid and the semilunar, this latter articulation constituting a sort of enarthrodial joint.

The Joints of the Distal Row of Carpal Bones.—The **ligaments** of these joints are transverse *posterior* or *dorsal* and *palmar* or *volar* bands

connecting the surfaces of contiguous bones (Fig. 73) and three *interosseous ligaments* interposed between the bones. The interosseous ligament between the trapezium and trapezoid is near the palmar surface, that between the trapezoid and magnum is near the dorsal surface, while the one connecting the magnum and unciform is near the distal portions of those bones.

The **movements** of the mid-carpal joint are flexion and extension, with a slight degree of rotation permitted by the form of the articulation between the head of the magnum and the scaphoid and semilunar (Fig. 73). The **synovial membrane** will be referred to below.

THE CARPO-METACARPAL ARTICULATIONS.—With the exception to be noted below, *i.e.*, the joint between the trapezium and the metacarpal bone of the thumb, these joints are of the **arthrodial** type. The **ligaments** are *dorsal*, *palmar* or *volar*, and two *interosseous*. The **dorsal** bands, stronger than the volar ligaments, connect the trapezium and trapezoid

FIG. 76.—Lower end of right radius in supination..

with the second (index) metacarpus, the trapezoid and magnum with the third metacarpus, the magnum and the unciform with the fourth, and the unciform with the fifth. The **palmar** ligaments have a somewhat similar arrangement, the third metacarpus, however, being connected with three carpal bones, the trapezium, the magnum and the unciform. The **interosseous** ligaments connect the bases of the third and fourth metacarpals with the contiguous distal angles of the magnum and unciform. After the dissection of a few of the dorsal and palmar ligaments, the joints between the unciform and magnum and the third and fourth metacarpi should be opened from the dorsal surface to expose the interosseous ligaments.

The Articulation of the Trapezium with the First Metacarpus.—This is a **saddle=joint** or joint by **reciprocal reception.** The **ligament** is a *capsule*, which should be incised to permit of inspection of the articular surfaces, which are mutually adapted to each other by the fact that one presents a concavity corresponding to the convexity of the other. The **motion** permitted is thus very free, including flexion and extension, abduction, adduction and circumduction.

The Synovial Membrane of the Carpus.—This membrane occupies all the joints of the proximal row of carpal bones save that between the pisiform and the cuneiform, the cavity of the mid-carpal joint, all the joints of the distal row of bones and all the carpo-metacarpal joints except that between the trapezium and the metacarpal bone of the thumb.

THE INTERMETACARPAL ARTICULATIONS.—The bases of the four inner metacarpal bones articulate with each other by small articular facets and are held together by transversely directed **dorsal** and **palmar ligaments** (Fig. 75) and by **interosseous ligaments.** One or two of the joints should be opened.

The **transverse metacarpal ligament** connects the distal extremities of these bones on their palmar aspects.

THE METACARPO-PHALANGEAL ARTICULATIONS.—These **condyloid** joints between the heads of the metacarpal bones and the bases of the proximal phalanges are provided with **lateral ligaments** in the form of strong bands and **anterior** or **volar** or **glenoid ligaments,** grooved for the flexor tendon (Fig. 66). One of the volar ligaments should be reflected as shown in Fig. 75. The place of a posterior ligament is supplied by the extensor tendon and its aponeurosis. One of these should be reflected without disturbing the synovial membrane, as shown in the case of the little finger in Fig. 73.

The **movements** of these joints are chiefly flexion and extension; to a less degree, abduction, adduction and circumduction.

THE INTERPHALANGEAL ARTICULATIONS (articulationes digitorum manus).—The **ligaments** of these **ginglymus** joints are, as in the preceding case, the *anterior* and the two *lateral*, the place of the posterior ligament being supplied by the extensor tendon (Fig. 73).

The **bones of the forearm** should be studied at this stage (a), as to their relations to each other, (b), their relations to the surrounding muscles and hence to the surface, and (c), their salient anatomical features.

From their relations to each other and to the interosseous space as pointed out above (p. 151) it is evident that in general the most favorable position in which to place the forearm in treating a fracture of one or both bones is midway between pronation and supination, since in this position the space is least encroached upon. An exception to this general rule is found in fracture of the radius above the insertion of the pronator radii teres. In this fracture the upper fragment will be fully supinated by the action of the biceps, and if, therefore, the limb be dressed in the semi-prone position and union occurs with the upper fragment supinated and the lower semi-prone, the supinating function of the biceps will be lost.

The **ulna** in its relation to surrounding muscles has been sufficiently considered (p. 101). *Fracture of the olecranon* is of rather frequent occurrence, this process being displaced upward in such a fracture by the action of the triceps. Fracture of the coronoid process is mentioned on p. 100. The *upper epiphysis*, including only the upper part of the olecranon, unites with the shaft at the sixteenth year; the dissector should make an effort to trace the line of epiphyseal union as it passes downward and backward from the upper and front part of the greater sigmoid cavity. The *lower*

epiphysis, including the articular surfaees and the styloid proeess, unites with the diaphysis in the eighteenth year; it is rarely separated by injury. The *shaft* of the ulna is liable to fracture at any point, the practically subcutaneous situation of much of it accounting for the ease with which fractures become eompound.

The **radius**, as previously noted (p. 101), is quite embedded in muscles above, where the bone is most slender, but is less well protected below. Partly for this reason and partly for mechanical reasons having to do with its relation to the wrist and hand, fraetures of the bone increase in frequency from above downward, the fracture of Colles, the seat of which is at some point within two inches of the lower end of the bone, being one of the most common of all fractures. The *lower epiphysis* unites with the diaphysis in the eighteenth or nineteenth year; its line of union is about three fourths of an inch above the apex of the styloid process and about one fourth of an inch above the lower extremity on the ulnar side of the bone. Separation of the lower epiphysis is quite common and may be mistaken for Colles' fracture. The *upper epiphysis*, comprising the head, unites with the diaphysis in the fifteenth year and is not frequently separated by violenee, exeept possibly in partial degree in very young children.

CHAPTER II

THE LOWER LIMB.

THE dissector of the lower limb, in accordance with the general scheme of the arrangement of the work on the cadaver, begins his work with the dissection of the gluteal region, after the completion of which he works out the structures of the popliteal space, then those of the dorsal

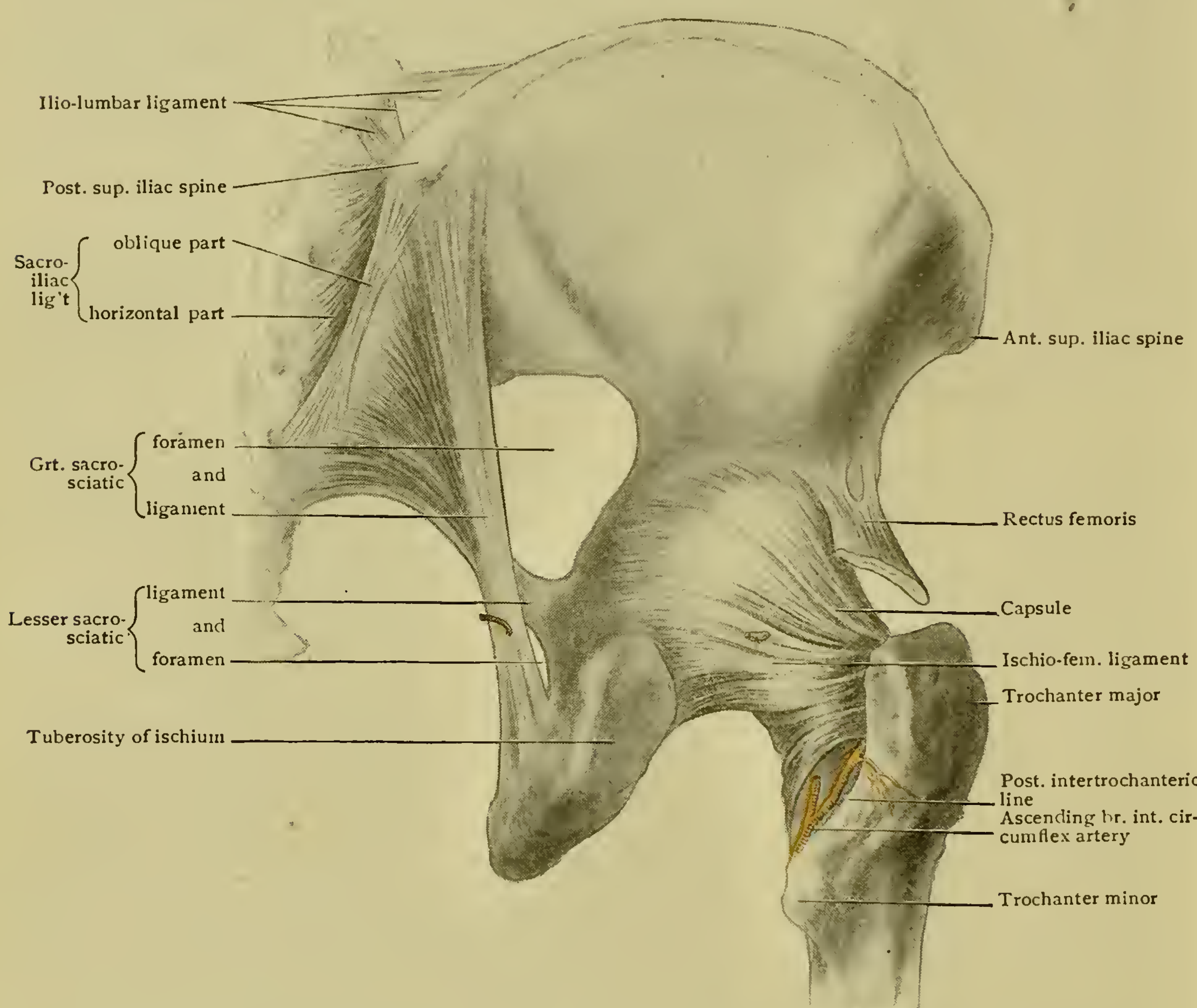

FIG. 77.—Dissection of posterior aspect of hip-joint and sacro-iliac and sacro-sciatic ligaments.

aspect of the thigh. The work on these regions is to be completed in the time allotted to the dissectors of the upper limb and of the abdomen and thorax for the dissection respectively of the dorsal aspect of the shoulder and the dorsal surface of the trunk. Before undertaking the dissection, the bones involved should be reviewed, the student procuring a bony pelvis and a femur, or studying the parts in the articulated skeleton.

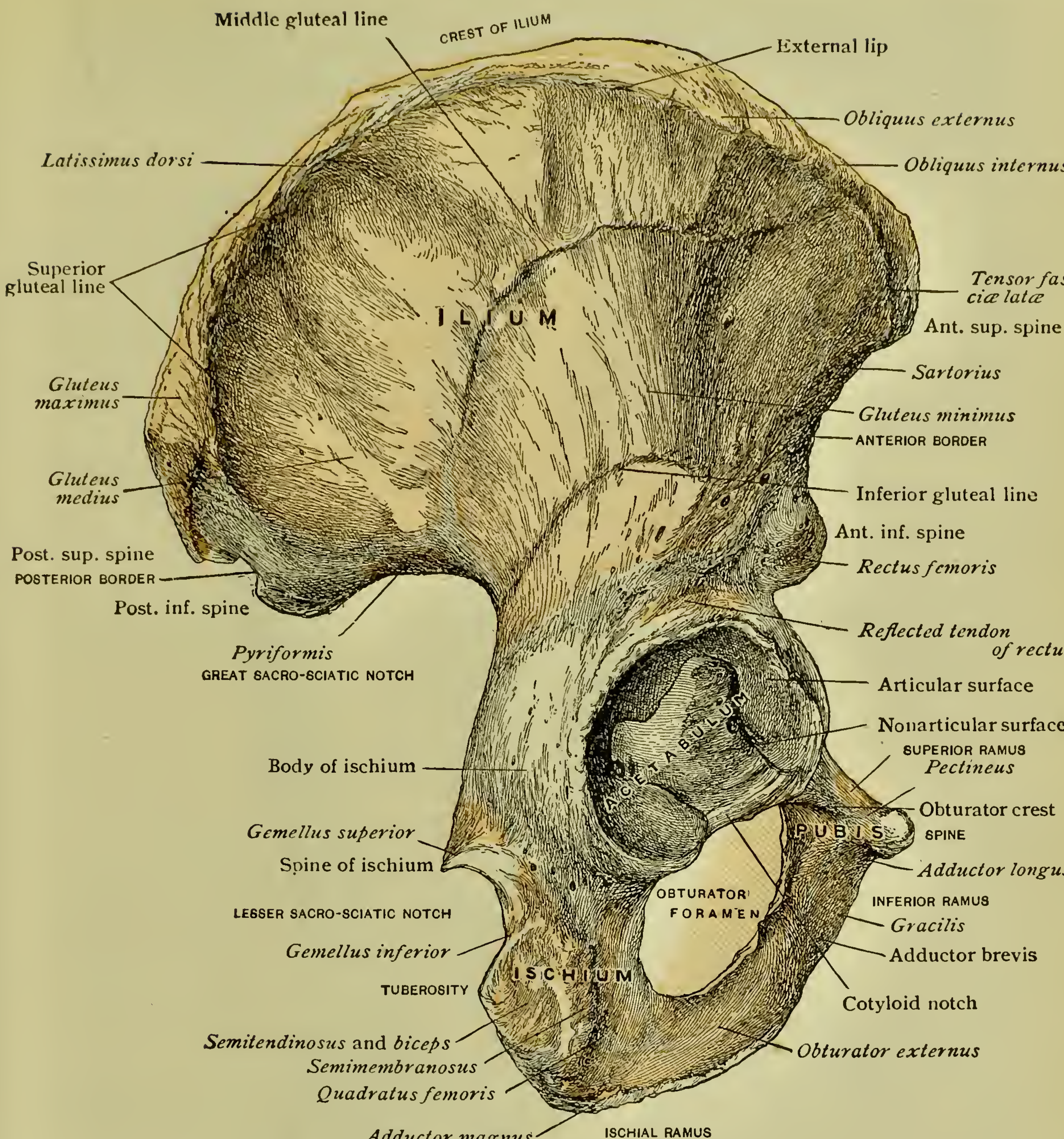

FIG. 78.—Right innominate bone, outer aspect.

The Postero-Lateral Aspect of the Bony Pelvis.—The **dorsum of the ilium** or outer surface (Fig. 78), subdivided into areas for the several attachments of the three gluteal muscles by the *superior*, the *middle* and the *inferior gluteal lines*, presents above, the **crest,** with its *anterior* and *posterior superior spines*, and in front a short concave **anterior border** which terminates below in the *anterior inferior spine*, while behind is a still shorter **posterior border** with its *posterior inferior spine*. The **inferior**

border is continuous in its anterior half or more with the ischium and pubis with which it forms the **acetabulum,** while its remaining part is free and forms part of the boundary of the great **sacro-sciatic notch.**

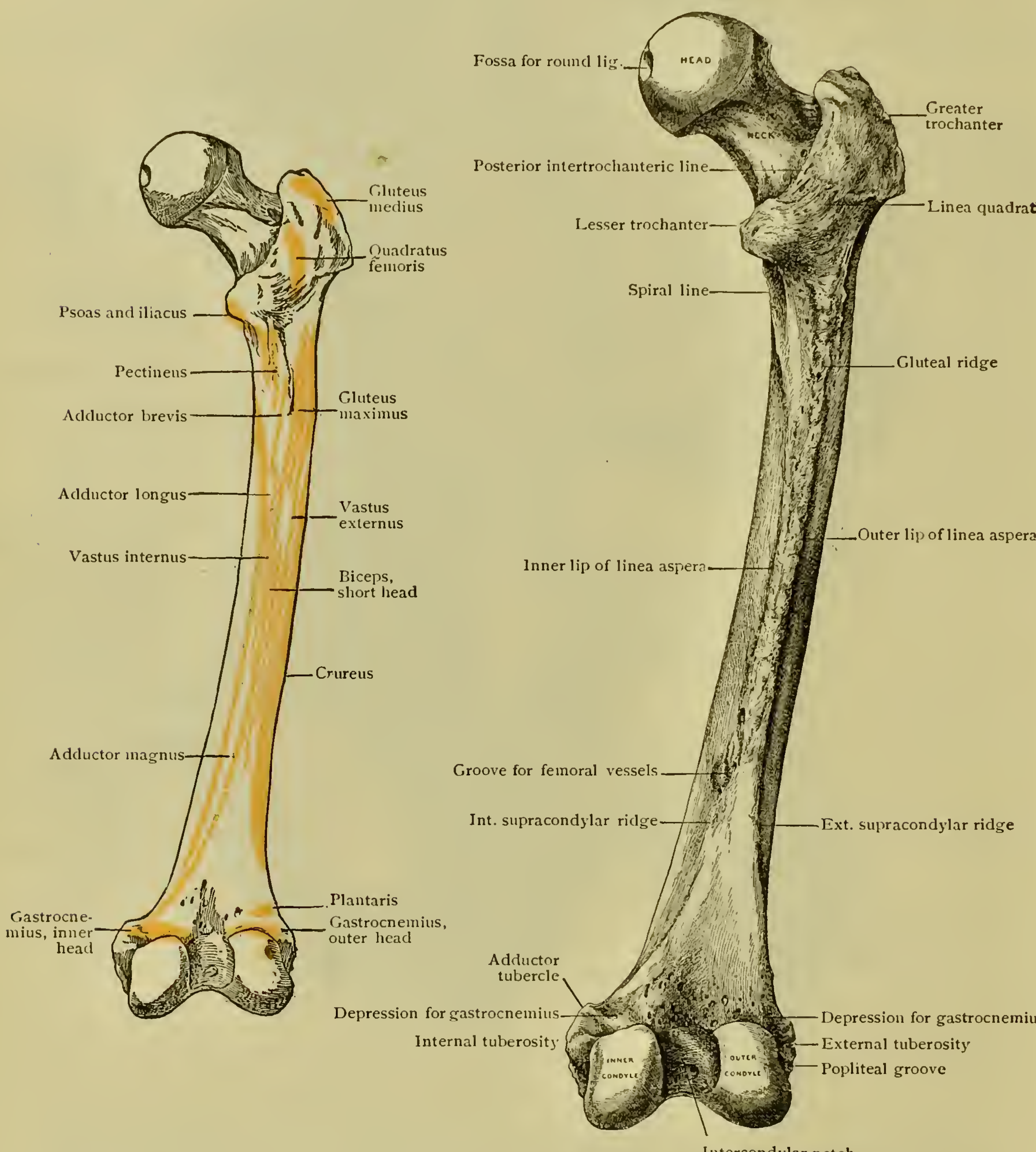

FIG. 79.—Right femur from behind. The outline figure shows the areas of muscular attachment.

The **body of the ischium** (Fig. 78) contributes to the acetabulum a little more than two fifths of that cavity, and its *posterior border* bounds the great sacro-sciatic notch in front. The dorsally projecting **ischial spine** divides the greater sacro-sciatic notch, which is above it, from the

lesser sacro-sciatic notch situated below. The **tuberosity of the ischium,** massive and marked by ridges and impressions for muscular and ligamentous attachments, helps to bound the **obturator** or **thyroid foramen** and presents a groove just below the acetabulum for the obturator externus. The **ramus of the ischium** passing forward from the tuberosity joins the **vertical** ramus of the pubis and with the latter forms a large part of the circumference of the foramen obturatum.

The **dorsal aspect of the sacrum** (Fig. 77), with its *tubercles* and *posterior sacral foramina*, is noteworthy, as are also the **coccyx** and the **greater** and **lesser sacro-sciatic ligaments** and the **greater** and **lesser sacro-sciatic foramina.** The student should note that the greater ligament bounds both foramina behind (Fig. 78), the two foramina being separated from each other by the lesser ligament and by the spine of the ischium, and that the lesser ligament is anterior to the greater.

The Posterior Aspect of the Femur.—The parts of the femur to be noted in this connection (Fig. 79) are the **head,** the **neck** with the *posterior intertrochanteric* line, the **great trochanter** with its *digital fossa* on its inner aspect, the **linea aspera** and its upper and lower diverging *lips*, the latter enclosing the *popliteal surface* of the femur, and the **linea quadrati,** a vertical line or ridge which intersects the posterior intertrochanteric line.

THE GLUTEAL REGION.

SURFACE ANATOMY.

The **crest of the ilium** with its **anterior superior spine,** and its **posterior superior** and **posterior inferior spines** (p. 161), is easily recognizable. The **tubercles of the sacrum** and the **tip of the coccyx** are also recognizable by touch. The margin of the great sacro-sciatic foramen is obscurely palpable, while the **tuberosity of the ischium** and the **great trochanter of the femur** are rather conspicuous landmarks. The rounded contour of the buttock is due in large measure to the gluteus maximus muscle. The **gluteo-femoral fold** or **sulcus** (Fig. 80), a transverse crease below the buttock, delimiting the latter from the posterior surface of the thigh, is quite conspicuous in extension of the thigh, but does not indicate the lower border of the gluteus maximus, which corresponds with a line extending downward and outward.

This gluteo-femoral fold is partially or totally obliterated in the early stage of *coxalgia* by reason of the slight degree of flexion in which the thigh is fixed by the muscles in that disease. The rounded contour above mentioned is also impaired to some extent in the same disease, owing to wasting of the muscles from disuse.

The bony prominences mentioned have some important practical applications, as for example the use of the anterior superior spine and the tuberosity of the ischium in the striking of **Nélaton's line,** which is drawn between these two points to determine shortening of the femur. This line under normal conditions crosses the tip of the great trochanter, so that displacement of the trochanter above this line would

indicate shortening from fracture of the femoral neck, or some form of dislocation of the femur. **Bryant's line** utilizes the anterior superior spine of the ilium from which to drop a line at right angles to the long axis of the trunk, the distance between this line and the great trochanter being measured on both sides of the body and compared, lessening of this distance indicating shortening of the corresponding femur.

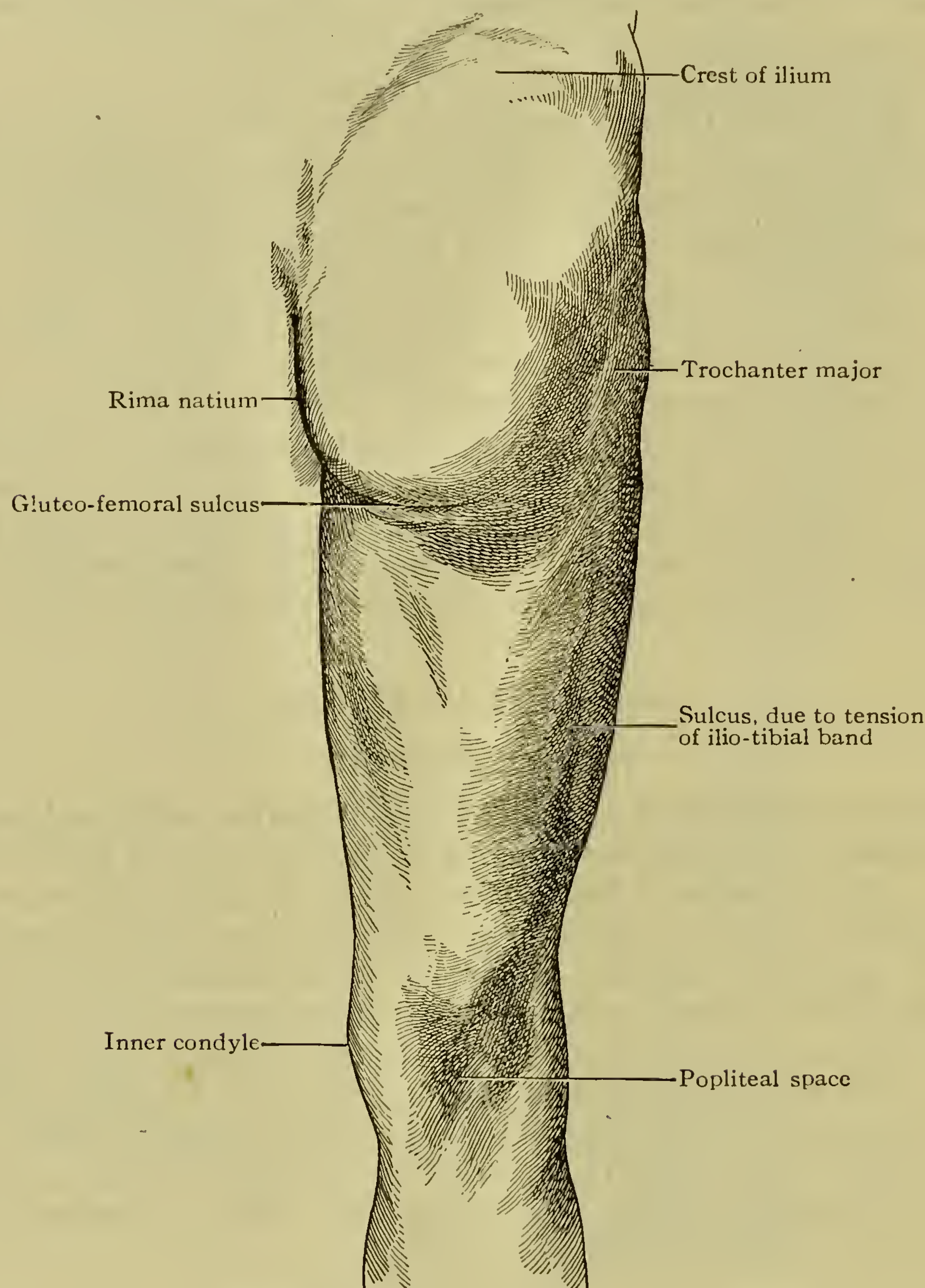

FIG. 80.—Surface anatomy of the gluteal region and the posterior aspect of the thigh and knee.

DISSECTION.

The skin of the buttock, which is of coarse texture, should be reflected by making an incision along the line of the crest of the ilium and one along the mid-line of the sacrum (Fig. 80). The reflection of the skin should be begun at the upper mesial corner and the flap should be turned

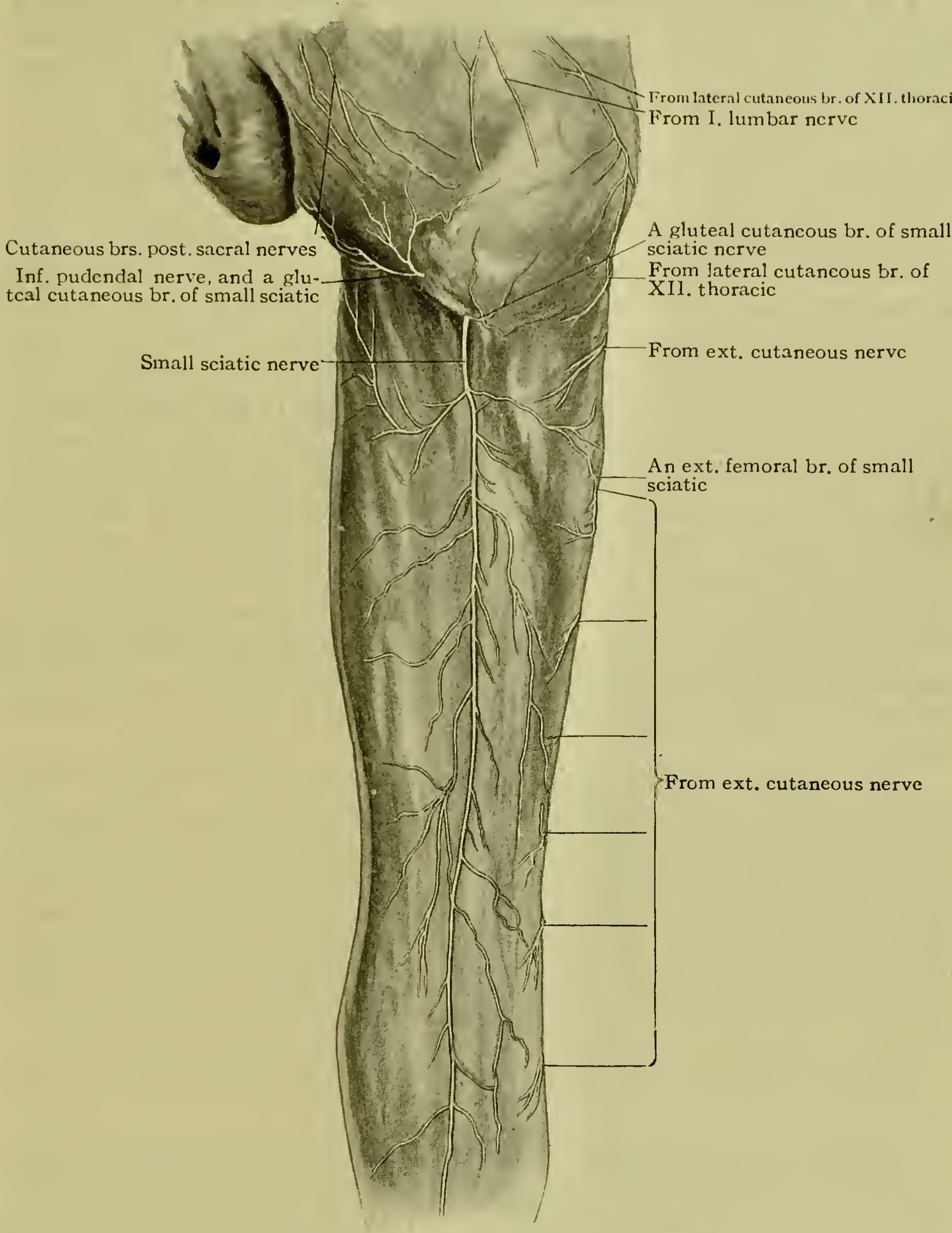

FIG. 81.—Superficial dissection of right buttock and thigh, showing cutaneous nerves of posterior surface.

outward. A transverse incision may be added slightly below the gluteo-femoral fold. The dissection is rather facilitated if the cadaver's leg and thigh are dropped over the edge of the table in order to make tense the gluteus maximus.

The Superficial Fascia.—The superficial fascia may be the seat of excessive fatty deposit according to the peculiarity of the individual. Although theoretically containing the **superficial vessels** and **nerves,** practically these will be found beneath the superficial fascia except as to their terminations. The **lateral cutaneous branch** of the twelfth dorsal nerve will be found just below the crest of the ilium and about one inch back of its anterior extremity (Fig. 11), lying upon the deep fascia. Having been found, it should be picked up and traced to its distribution upon the anterior portion of the buttock. The **iliac branch of the ilio-hypogastric nerve** (Fig. 11) will be found a short distance back of the preceding nerve, having crossed the crest of the ilium after perforating the external oblique muscle in order to reach its area of distribution upon the buttock. **Cutaneous branches of the lumbar nerves** will be found in varying degree upon the region of the buttock below the iliac crest and posterior to the distribution of the nerves last mentioned as well as some **cutaneous branches of the dorsal divisions of the sacral nerves** (Fig. 81). Having isolated these nerve-trunks the superficial fascia may be reflected as a flap in the same direction as the skin, the dissector searching in the neighborhood of the lower border of the gluteus maximus muscle for some **cutaneous branches of the inferior gluteal nerve** which curve around the lower border of the muscle to reach their cutaneous distribution, or which may pierce the muscle near its lower border.

The Deep Fascia.—Beginning at the crest of the ilium anterior to the position of the gluteus maximus (Fig. 82) the deep fascia may be traced from its attachment to the iliac crest downward over the gluteus medius muscle to the outer border of the gluteus maximus, where it splits into two layers which enclose the latter muscle between them. Traced downward, the superficial layer of the deep fascia will be seen to be continuous with the deep fascia of the thigh below the border of the muscle, at which point it is joined on its deep surface by the deep layer.

Thus a collection of blood or pus within the gluteus maximus will be enclosed between the two layers of the deep fascia.

Gluteus Maximus (Fig. 83).—**Origin,** the crest and outer surface of the ilium posterior to the superior gluteal ridge, the posterior surface of the sacrum and coccyx and the posterior surface of the great sacro-sciatic ligament; **insertion,** the fascia lata by a tendon and the gluteal ridge of the femur between the attachments of the adductor magnus and the vastus externus; **nerve-supply,** the fifth lumbar and first and second sacral nerves through the inferior gluteal; **action,** extension of the thigh upon the trunk and external rotation.

Denude this muscle by incising the enveloping layer of fascia near the origin of the muscle and dissecting in the course of the muscular

bundles, noting the extreme coarseness of the latter. After its complete exposure it should be detached along its line of origin and reflected outward. In doing this, one must proceed cautiously in order to avoid

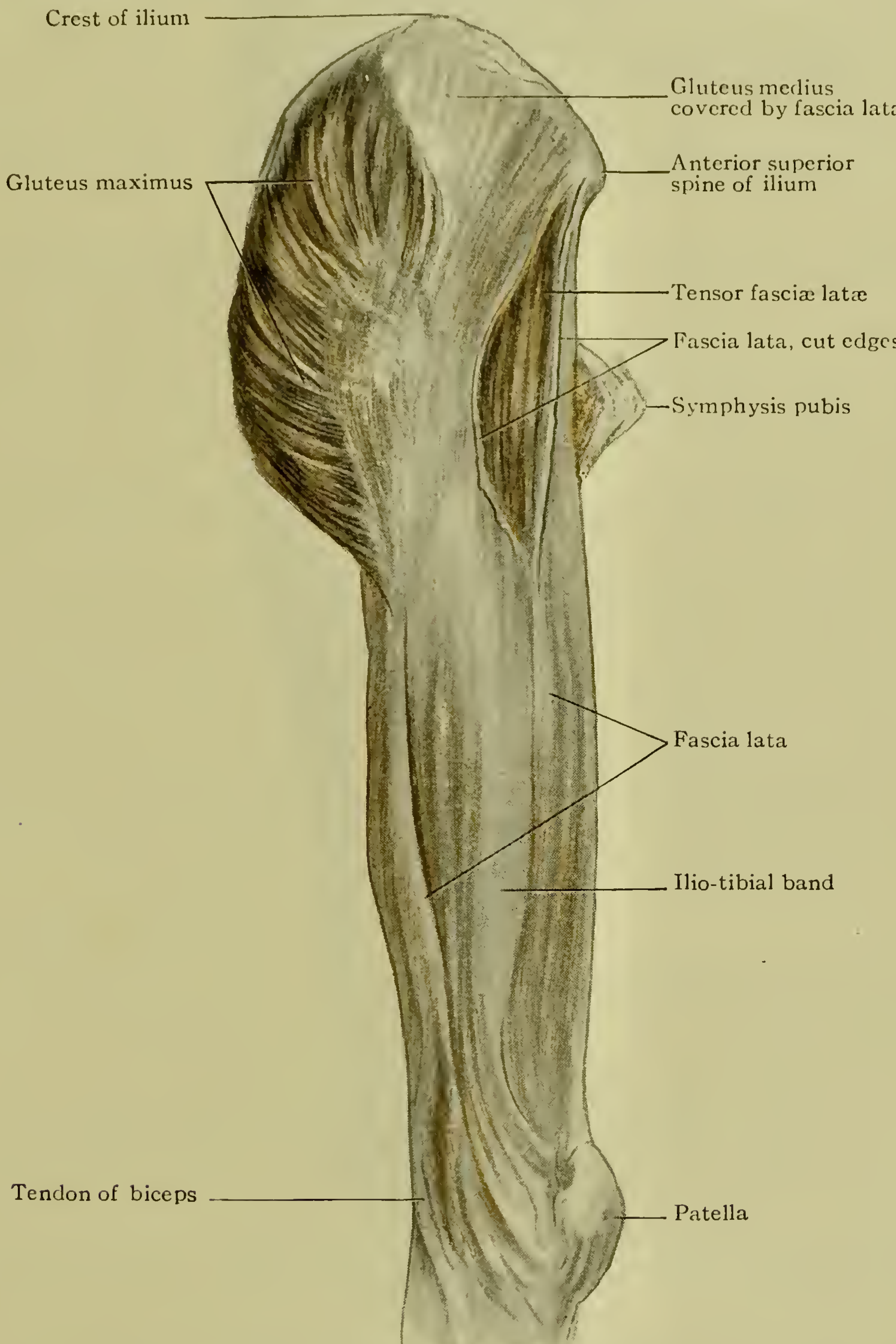

FIG. 82.—Lateral surface of right thigh invested by fascia lata.

nerves and vessels which are encountered at various points in proximity to the line of origin. In raising the upper part of the muscle the superior gluteal artery and nerve will be encountered at their emergence through

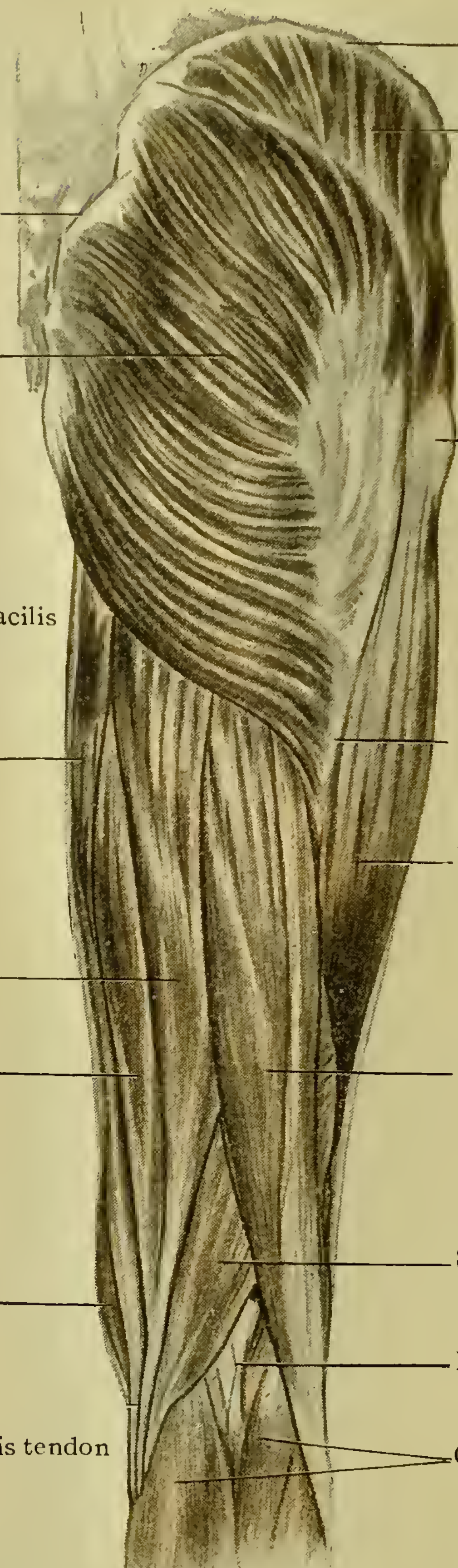

Fig. 83.—Superficial dissection of posterior surface of right buttock and thigh, showing muscles undisturbed.

the upper part of the great sacro-sciatic foramen, the artery sending some muscular branches to the gluteus maximus which must necessarily be sacrificed in reflecting the muscle. Nearer the sacrum, and farther down, the inferior gluteal nerve as well as other nerve trunks, and the sciatic artery, emerging through the lower part of the foramen, are to

be avoided. In raising that part of the muscle which arises from the great sacro-sciatic ligament, the **perforating cutaneous nerve,** a branch of the fourth sacral nerve which perforates the ligament in common with the coccygeal artery, is also to be avoided. Some of the muscular branches to the gluteus maximus which come from the inferior gluteal nerve enter the deep surface of the muscle not far from the edge of the great sacro-sciatic ligament. These may be left attached to the muscle for the present at least. The tuberosity of the ischium, now exposed, presents on its superficial aspect a **bursa** which is usually easily demonstrable.

Inflammation of this bursa is known as "weaver's" or "lighterman's bottom"; it results from the irritation of much sitting.

Gluteus Medius (Fig. 84).—**Origin,** the outer surface of the ilium between the superior and middle gluteal lines; **insertion,** the outer surface of the great trochanter of the femur; **nerve-supply,** the third and fourth sacral nerves through the superior gluteal nerve; **action,** extension of the thigh and either external or internal rotation of the thigh, according as the posterior or anterior parts of the muscle act.

The deep fascia should be removed from the upper and anterior portion of the muscle and the rather soft cellular tissue should be removed from the remaining part of its surface. The muscle may be incised about three inches from its insertion by an incision transverse to the direction of its fibres, and the proximal portion may be cautiously reflected upward and inward, taking care to avoid injuring the nerves and vessels beneath it. The distal portion may also be reflected or at least elevated, and the **bursa** which separates the terminal part of the muscle from the anterior portion of the outer surface of the great trochanter may be looked for.

The **gluteal artery** (a. glutæa superior), a branch of the posterior trunk of the internal iliac, or rather the continuation of that trunk, emerges through the upper part of the great sacro-sciatic foramen (Fig. 84). Giving some branches to the deep surface of the gluteus maximus muscle, it divides into a **superficial** and a **deep branch.** The **superficial branch** divides into vessels some of which are distributed to the great gluteal muscle while others perforate it near its origin to anastomose over the dorsal surface of the sacrum with the dorsal branches of the sacral arteries. The **deep branch** further divides into an *upper* and a *lower trunk*. The *upper trunk* ascends toward the crest of the ilium and makes its way along the upper border of the gluteus minimus toward the anterior superior iliac spine, where it anastomoses with the deep circumflex iliac and the ascending branches of the external circumflex of the profunda femoris (p. 205); the *lower branch* of the deep division passes over the surface of the gluteus minimus muscle toward the great trochanter, sending branches to the muscles and to the hip-joint. In

tracing these arterial trunks one must exercise care to avoid injuring the nerves which are in intimate association with them.

The importance of the anastomosis formed by the superior gluteal artery is indicated on p. 206. This vessel is sometimes the seat of aneurism. It is also sometimes injured in stab wounds of the buttock. For either condition its ligation may be necessary. It may be located at the junction of the upper third with the middle third of a line drawn from the posterior superior spine of the ilium to the great trochanter of the femur.

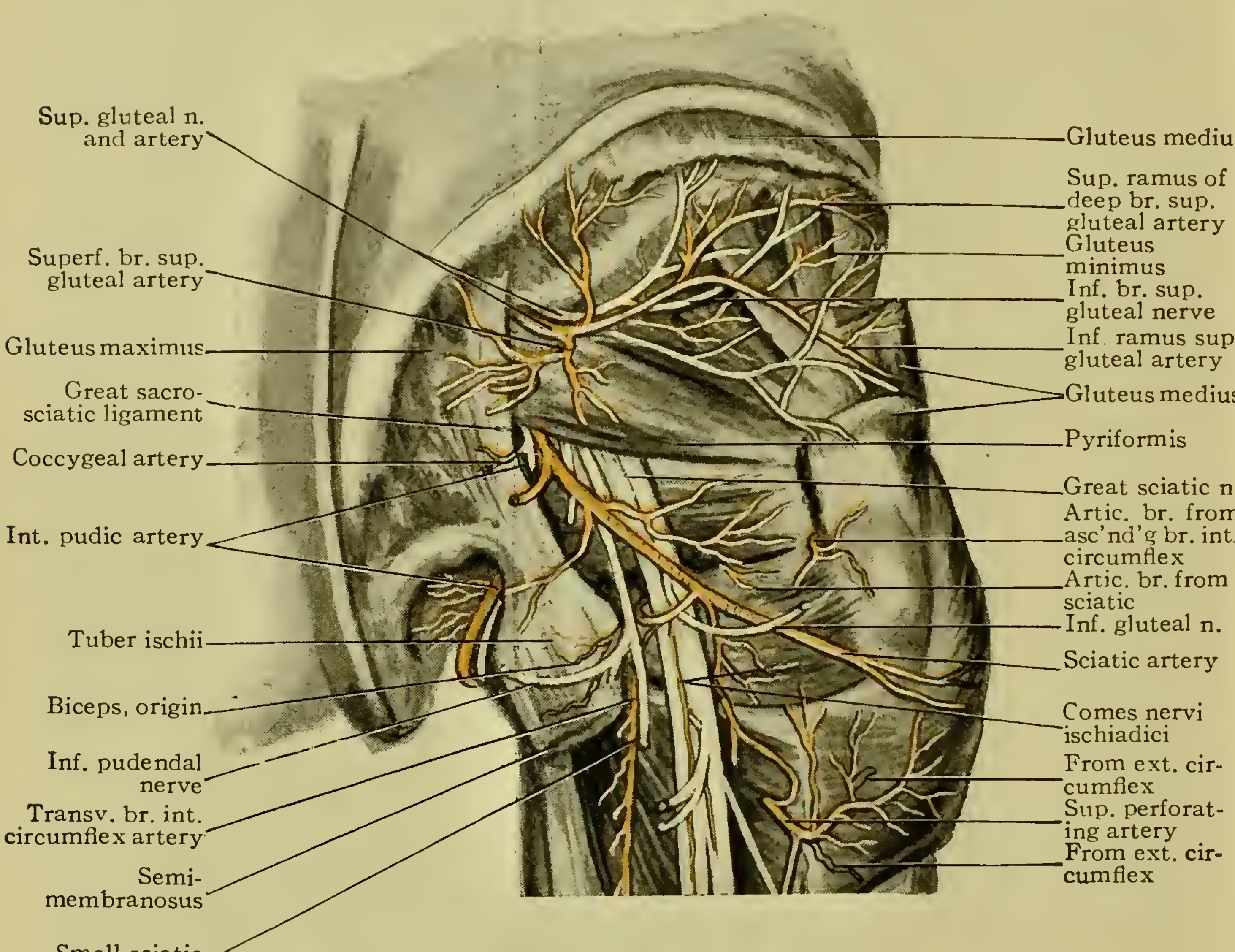

Fig. 84.—Deep dissection of right gluteal region.

The **superior gluteal nerve**[1] (Fig. 85), a branch of the sacral plexus deriving its fibres from the fourth and fifth lumbar and first sacral nerves, emerges through the upper part of the great sacro-sciatic foramen and distributing *muscular branches* to the superficial surface of the gluteus minimus (*inferior branch*) and the deep surface of the gluteus medius (*superior branch*), it passes forward between these two muscles toward the anterior inferior spine of the ilium and terminates by supplying the tensor fasciæ femoris muscle. These branches should be carefully followed out.

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[1] n. glutæus superior.

Gluteus Minimus (Fig. 86).—**Origin,** the outer surface of the ilium between the inferior and middle gluteal lines; **insertion,** the anterior border of the great trochanter of the femur; **nerve-supply,** the fourth and fifth lumbar and first sacral nerves through the superior gluteal nerve; **action,** abduction of the thigh and internal rotation.

The surface of this muscle should now be denuded, care being taken to preserve the arteries and nerves just dissected.

Pyriformis (Figs. 86 and 87).—**Origin,** by three fleshy processes from the front surface of the sacrum between the first and second, the second and third, and the third and fourth anterior sacral foramina and from the margin of the great sacro-sciatic foramen; **insertion,** the upper border of the great trochanter; **nerve-supply,** the first and second sacral nerves through the sacral plexus; **action,** external rotation of the thigh.

This muscle should be dissected from the point where it emerges through the great sacro-sciatic foramen, the aperture through which it emerges from the pelvis, note being taken of its partial origin from the upper and posterior border of the foramen as well as from the great sacro-sciatic ligament. Being a muscle of rather delicate texture, it is sometimes lacerated in the dissection and hence its dissection requires care. Denudation should be carried on to the tendon of insertion. Not infrequently the muscle will be perforated by the great sciatic nerve or by a part of this nerve.

The **small sciatic nerve**[1] (Fig. 84), a branch of the sacral plexus or of the pudendal plexus, composed of fibres derived from the second and third and sometimes the first sacral nerves, emerges from the pelvis through the great sacro-sciatic foramen below the pyriformis, being placed superficially to the great sciatic nerve and the sciatic artery. It should be traced to the lower margin of the dissection and preserved, to be more particularly examined later.

The **sciatic artery** (a. glutæa inferior), a rather large vessel, will be found at the lower border of the pyriformis near the great sacro-sciatic ligament (Fig. 84). It is one of the terminal branches of the anterior trunk of the internal iliac, emerging from the pelvis through the great sacro-sciatic foramen below the pyriformis. Its **branches,** as it passes downward and outward, are the *coccygeal,* which, passing inward, pierces the great sacro-sciatic ligament and the origin of the gluteus maximus (Fig. 84) to reach the dorsal surface of the sacrum and coccyx; the *inferior gluteal,* which enters the deep surface of the gluteus maximus; *cutaneous* and *muscular* branches; the *comes nervi ischiadici,* which runs upon or in the substance of the great sciatic nerve; an *articular* branch to the hip-joint, which pierces the posterior part of the capsule of that joint usually below the combined tendons of the obturator internus

[1] n. cutaneus femoris posterior.

and the gemelli; the *anastomotic* branch, which terminates by anastomosing with the internal and external circumflex arteries and the superior perforating artery to form the *crucial anastomosis* at the upper back part of the thigh.

The **crucial anastomosis,** it will be seen, would assist in establishing the collateral circulation after ligation of the common femoral or of the external iliac. The accompanying artery of the great sciatic nerve, although usually a very small vessel, has been found enlarged to such an extent after ligation of the femoral artery as to have been one of the chief agents in carrying on the circulation by its anastomoses with the branches of the popliteal artery. For the location of the sciatic artery see p. 174.

The **inferior gluteal nerve** (Fig. 85), a branch of the sacral plexus derived from the fourth and fifth lumbar and the first and second sacral nerves, passes out of the pelvis through the great sacro-sciatic foramen below the pyriformis superficially to the great sciatic nerve and supplies the gluteus maximus muscle and the skin over the lower part of this muscle as previously indicated.

The Great Sciatic Nerve (n. ischiadicus).—This nerve-trunk, the largest in the body, is a branch of the sacral plexus, being composed of fibres derived from the fourth and fifth lumbar and the first, second, and third sacral nerves. It emerges from the pelvis through the great sacro-sciatic foramen below the pyriformis (Fig. 85), sometimes as a single trunk, sometimes in two divisions, in which latter case the two divisions may remain separate, constituting the internal and external popliteal nerves, or may reunite to divide later at any point short of the popliteal space into the internal and external popliteal nerves. This nerve should be traced to the lower limit of the dissection. An *articular branch* for the hip-joint may arise from it in the gluteal region.

Obturator Internus (Fig. 86).—**Origin,** the inner surface of the lateral wall of the pelvis including the upper and anterior margins of the obturator foramen (rami of pubis and ischium), the inner surface of the obturator membrane (Fig. 87) and the inner surface of the ischium behind the foramen. Passing downward its fibres converge to terminate in a tendon which passes out of the pelvic cavity through the lesser sacro-sciatic foramen to be **inserted** into the upper border of the great trochanter in common with the two gemelli muscles; **nerve-supply,** a branch from the sacral plexus; **action,** external rotation of the thigh.

In this dissection the dissector will encounter only the tendon of this muscle as it emerges from the lesser sacro-sciatic foramen. The tendon may be almost wholly obscured by muscular fibres which approach it from above and from below, these being respectively the gemellus superior and the gemellus inferior.

The **nerve to the obturator internus,** derived from the sacral plexus, crosses the muscle or its tendon near the emergence of the latter from the pelvis (Fig. 85), the nerve leaving the pelvis through the greater foramen.

The Gemelli Muscles (Fig. 86).—**Origin,** the **superior** from the upper border of the lesser sacro-sciatic foramen, *i.e.*, the spine of the ischium; the **inferior** from the lower border of this aperture, or the tuberosity of the ischium; **insertion,** the tendon of the obturator internus and

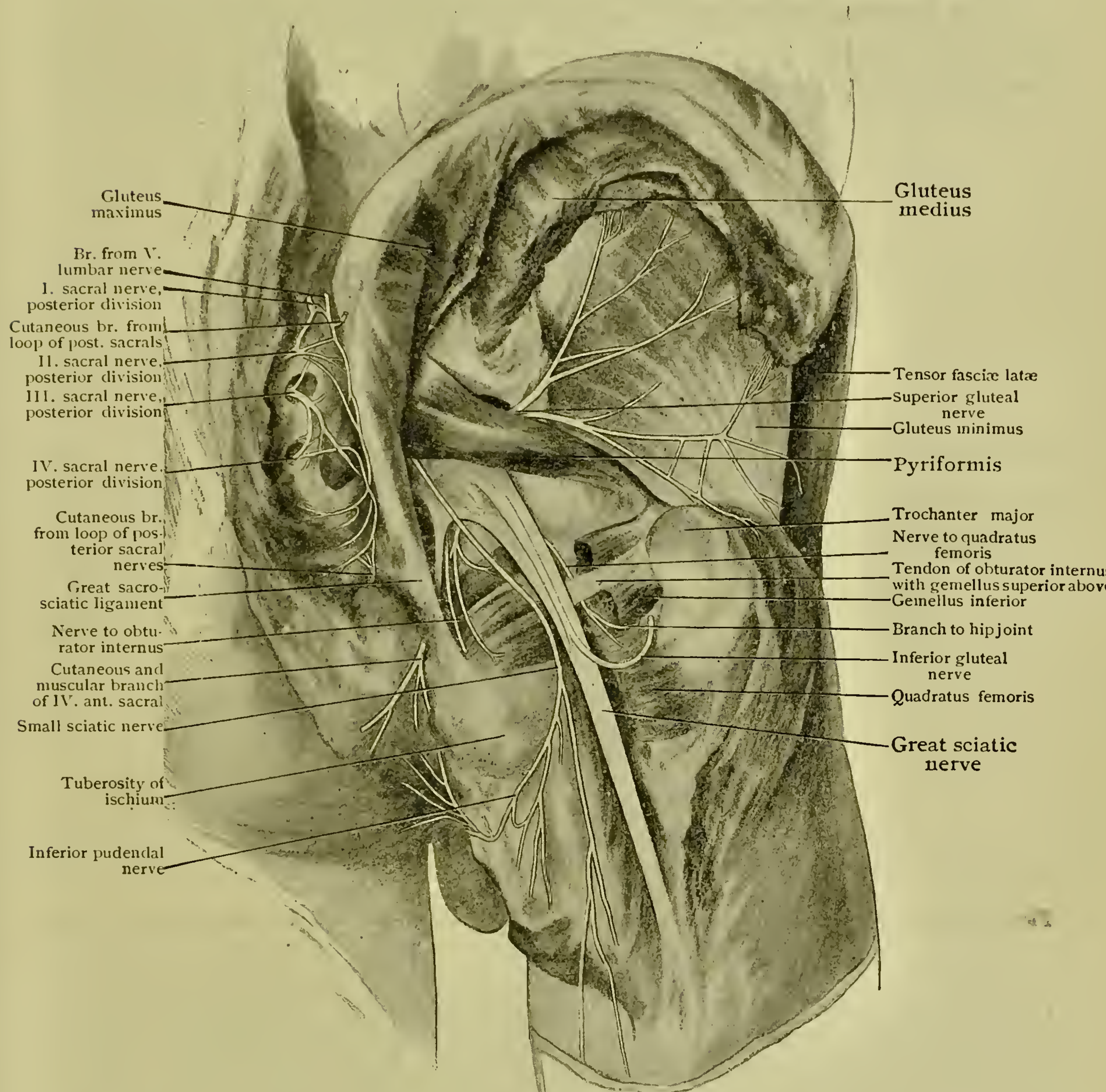

Fig. 85.—Deep dissection of right buttock, showing emergence of great sciatic nerve below pyriformis muscle; also muscular branches and posterior divisions of sacral nerves.

the great trochanter; **nerve-supply,** the sacral plexus, the fibres for the superior gemellus by way of the nerve to the obturator internus, while those for the lower muscle reach it by way of the branch to the quadratus femoris; **action,** external rotation of the thigh.

In cleaning these muscles, the nerves of supply will be found entering their superficial surfaces. If the thigh be slightly rotated inward to relax the muscles and thus to permit of their being to some extent inverted, a small nerve-trunk will be found passing under the muscles downward and outward to reach the quadratus femoris muscle.

The **internal pudic artery** (a. pudenda interna), a terminal branch of the anterior trunk of the internal iliac, comes out of the pelvis through the great sacro-sciatic foramen in company with the pudic nerve, and

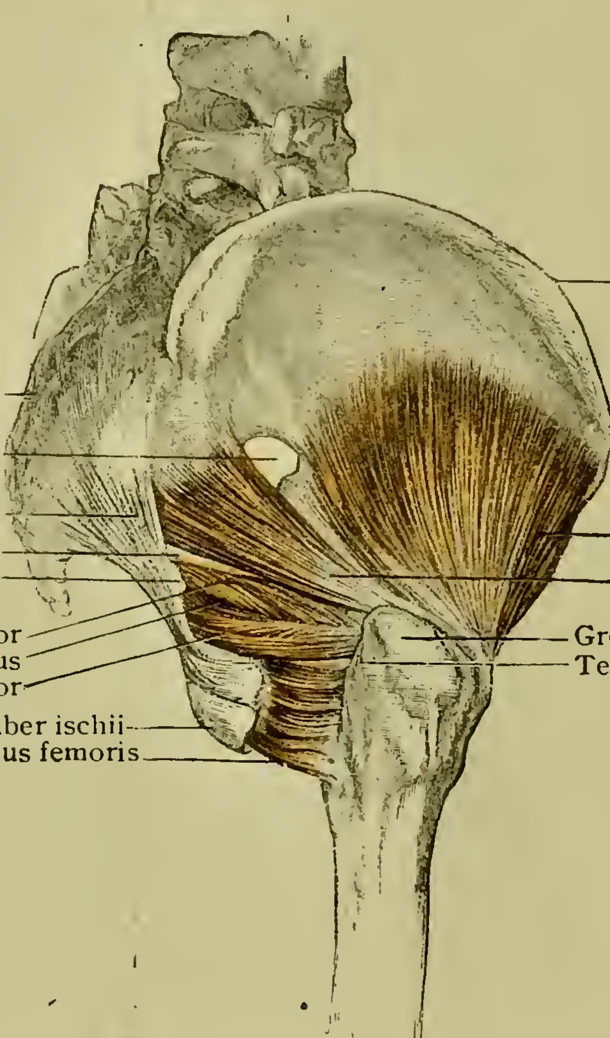

FIG. 86.—Deep dissection of the right buttock, showing muscles attached to greater trochanter of femur.

crossing externally the spine of the ischium passes through the lesser sacro-sciatic foramen to enter the outer part of the ischio-rectal fossa. The artery is quite well hidden under the border of the great sacro-sciatic ligament. Having discovered the vessel it may be pulled out slightly by a director or blunt hook, that it may be thoroughly denuded. It gives off no noteworthy branches here; its further course belongs to the dissection of the perinæum (Fig. 84).

To locate the internal pudic and sciatic arteries for the purpose of ligating them for wound or aneurism, they may be found at the junction of the middle third with the lower third of a line drawn from the posterior superior spine of the ilium to the tuberosity of the ischium.

The **pudic nerve** (n. pudendus), a branch of the sacral (or pudendal) plexus, its fibres emanating from the second, third and fourth sacral nerves, will be found upon the inner side of the internal pudic artery under cover of the great sacro-sciatic ligament. Like its companion artery, it leaves the pelvic cavity through the great sacro-sciatic foramen below the pyriformis, crosses the spine of the ischium externally and traverses the lesser sacro-sciatic foramen to reach the ischio-rectal fossa.

Quadratus Femoris.—**Origin,** the outer surface of the tuberosity of the ischium; **insertion,** the linea quadrati of the femur (Fig. 84);

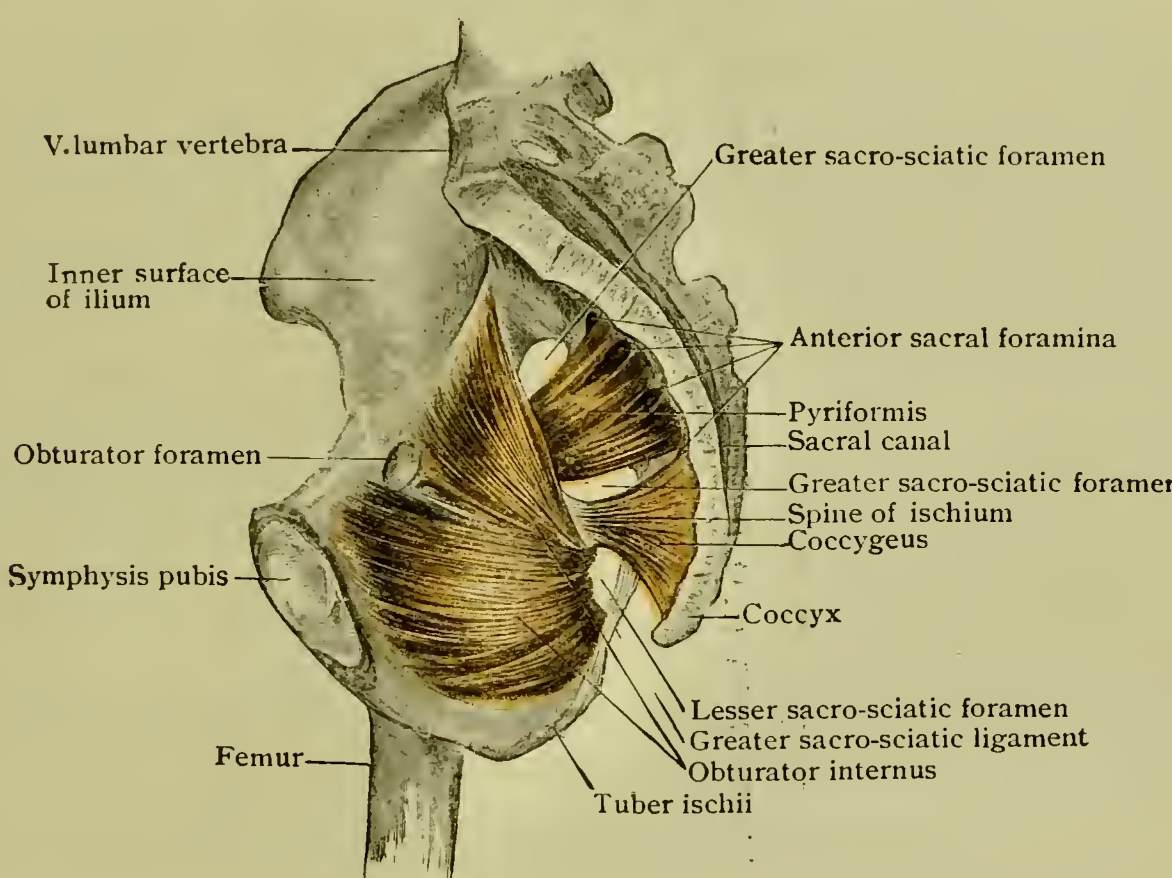

Fig. 87.—Dissection of right postero-lateral wall of pelvis from within, showing pyriformis and obturator internus muscles.

nerve-supply, the fourth and fifth lumbar and first sacral nerves through a branch from the sacral plexus; **action,** external rotation of the femur.

In cleaning this muscle the terminal portion of the internal circumflex artery will be encountered at its lower border near its outer extremity and the transverse branch of the internal circumflex near its inner extremity, between it and the adductor magnus, while immediately above it in a somewhat depressed interval will be found a portion of the obturator externus muscle and the termination of the ascending branch of the internal circumflex artery (Fig. 84).

The obturator externus muscle as it lies in relation with the posterior surface of the hip-joint capsule in the interval between the quadratus and the gemellus inferior should be isolated and elevated, the leg

being rotated inward to permit of the latter procedure, in order that its relation to the capsule of the joint may be properly noted. Occasionally the tendon of the muscle is quite intimately united with the capsule for as much as an inch before its termination.

The posterior aspect of the hip-joint can be examined most advantageously after the completion of the dissection of the posterior surface of the thigh.

THE POSTERIOR SURFACE OF THE THIGH AND THE POPLITEAL SPACE.

THE SURFACE ANATOMY.

This region presents no very special superficial landmarks, the muscular mass of the thigh flexors constituting the prominence and being responsible for the contour of this portion of the thigh, this convex contour giving way near the region of the knee to the concavity corresponding to the popliteal space (Fig. 80).

The region of the popliteal space, the depression at the bend of the knee, is lozenge-shaped, the upper half being bounded internally by a ridge which is due to the inner hamstring tendons (the semitendinosus, semimembranosus, the gracilis and the sartorius); it is bounded externally by a ridge due to the outer hamstring tendon or the tendon of the biceps. The lower half of the space is bounded on either side by the rounded eminence due to the presence of the corresponding head of the gastrocnemius muscle. Passing approximately through the mid-line of this space are the popliteal artery and vein.

DISSECTION OF THE POPLITEAL SPACE.

Two transverse incisions, one at a point about six inches above, and the other four or five inches below, the bend of the knee should be made, these being connected by a median longitudinal incision. The two skin-flaps thus outlined should be reflected in the usual manner.

The Superficial Fascia.—The superficial fascia presents here the usual characteristic adipose and cellular layers and, as usual, contains the ramifications of the superficial blood-vessels and nerves.

The **small sciatic nerve** (for origin see page 171) courses down the middle of the posterior aspect of the thigh beneath the deep fascia, piercing the latter structure at the upper part of the popliteal space. At this point the nerve should be sought and followed in its course through the mid-line of the space to the lower limit of the dissection. It will not be completely traced until later, since it usually terminates at about the middle of the leg or, occasionally, as low down as within three or four inches of the heel. Its *cutaneous branches* to the thigh

(p. 183) and leg are given off during its course, those to the thigh piercing the deep fascia at variable points. In the superficial fascia of the popliteal space **cutaneous nerves** are found along the inner and outer margins of the space, coming respectively from the internal and external popliteal nerves, the sural branch of the external popliteal or peroneal nerve piercing the deep fascia over the outer head of the gastrocnemius.

The **short** or **external saphenous vein,** ascending along the mid-line of the posterior surface of the leg, pierces the deep fascia opposite the bend of the knee to terminate in the popliteal vein. This should be cleaned down to the lower limit of the popliteal space; a *branch* of this vein may be found at or near the point where it pierces the deep fascia, this branch either passing upward a short distance to empty into the popliteal vein or, more commonly, passing upward and inward to join the internal saphenous vein (Fig. 88).

The **cutaneous arteries,** branches of the popliteal artery or of its muscular branches, are not especially noteworthy; one branch, the **superficial sural artery,** usually accompanies the short saphenous vein, having pierced the deep fascia near the lower angle of the space.

The Deep Fascia.—The deep fascia may be demonstrated by removing what is left of the superficial fascia after having isolated the structures mentioned above. The deep fascia of the popliteal region, the **popliteal fascia,** is thicker than that of the thigh, presenting numerous transverse bundles of fibrous tissue. The deep fascia should now be incised by a median longitudinal incision and the two flaps thus indicated should be reflected from the underlying muscles and other structures. In reflecting the flaps of the popliteal fascia, the **communicating popliteal nerve,** along the inner side of the lower half of the space, and the **communicating peroneal nerve,** at the outer angle of the space, or farther out beyond the limit of its outer boundary (Fig. 88) near the head of the fibula, should be found and isolated. These nerves may be found under the deep fascia, or upon its surface in the lower part of the dissection, converging toward the middle of the back of the leg.

The Boundaries of the Popliteal Space.—Externally, the outer hamstring tendon (tendon of the biceps) above, and the outer head of the gastrocnemius below; internally, the inner hamstring tendons (tendons of the semimembranosus, the semitendinosus, the gracilis and the sartorius) above, the inner head of the gastrocnemius below (Fig. 88).

Denuding the tendon of the biceps and as much of its fleshy mass as may come into relation with the space, one encounters on the inner side of this tendon the peroneal nerve.

This relation of the peroneal nerve to the tendon is of interest in connection with the operation of tenotomy (tendon-section) upon this tendon, which may be required for contracted knee, the nerve being exposed to injury unless care be exercised to avoid it.

The inner hamstrings should be dissected sufficiently to demonstrate their relation to the space; in the later dissection of the muscles of the back of the thigh they will be considered in detail.

The two heads of the **gastrocnemius muscle,** arising respectively from the inner and outer supracondylar ridges just above the inner and outer condyles of the femur, should be cleaned, thus demonstrating their relation to the popliteal space. The **plantaris muscle** (page 261), a

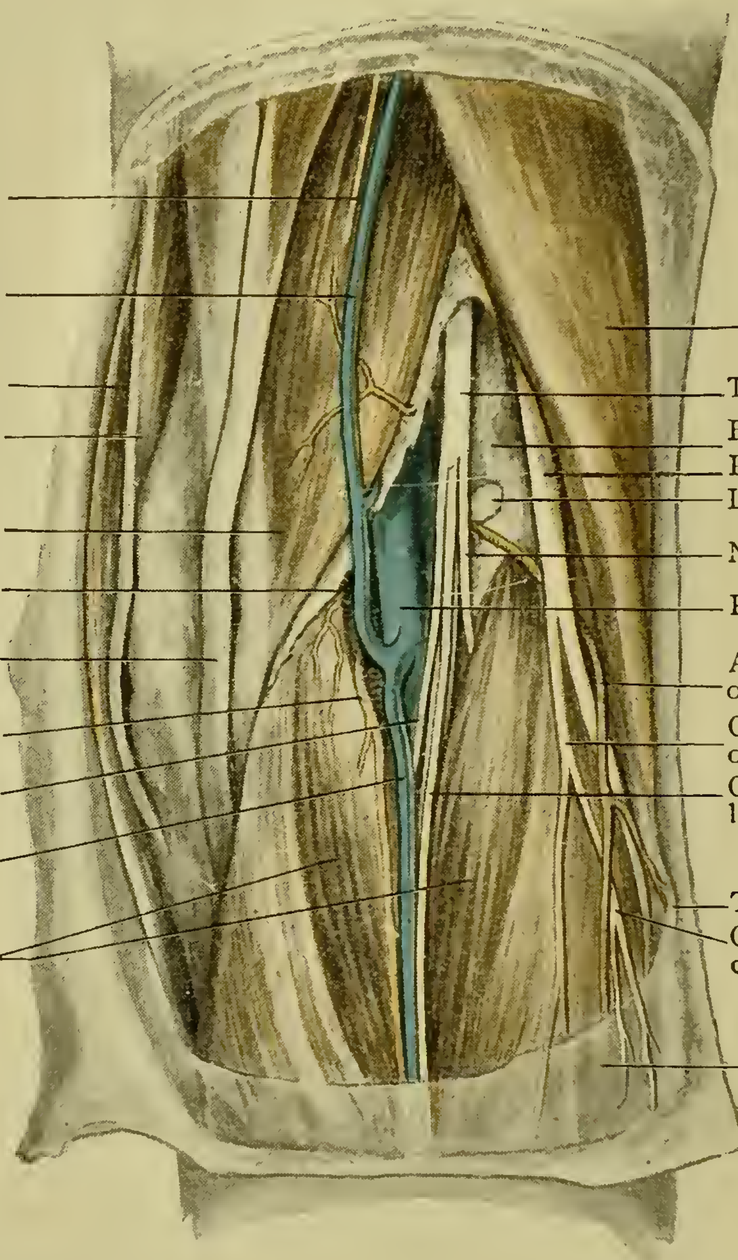

FIG. 88.—Dissection of right popliteal space, with structures *in situ.*

small fusiform muscular mass terminating in a slender tendon, associated with the outer head of the gastrocnemius and arising with it from the femur above the outer condyle, should also be isolated.

The **internal popliteal nerve,** or **tibial nerve,**[1] a terminal branch of the great sciatic, its fibres being derived from the fourth and fifth lumbar and the first, second and third sacral nerves, enters the popliteal space at its apex, lying superficially to the popliteal vein and artery, and upon

[1] n. tibialis.

their outer side above; passing through the middle of the space, it crosses the vein and artery superficially, lying upon their inner side below. Its further course will be seen in the dissection of the leg. Cleaning this nerve, the **branches** encountered will be first *cutaneous branches;* two or three *articular branches*, one of which is given off about opposite the interval between the tibia and femur and perforates the posterior ligament of the knee-joint with the azygos articular artery, a second accompanying the inferior internal articular artery, and a third, not always present, accompanying the superior internal articular artery; *muscular branches* to the two heads of the gastrocnemius, the plantaris, the soleus and the popliteus, found in the lower half of the space; and the *communicans poplitei* (or tibialis). The last named, a large cutaneous branch arising below the middle of the space, passes obliquely downward and inward to unite usually at some point above the middle of the leg with a similar branch from the external popliteal nerve to form the external saphenous nerve (Fig. 130).

The **external popliteal** or **peroneal nerve** (n. fibularis), a terminal branch of the great sciatic, its fibres coming from the fourth and fifth lumbar and the first and second sacral nerves, passes along the outer margin of the popliteal space upon the inner side of the tendon of the biceps to the head of the fibula, where it quits the popliteal space and, passing around the outer side of the head of the fibula, reaches the front of the leg (page 245). *Cutaneous* branches of this nerve to the skin of the popliteal space and one or more, the *sural*, to the skin of the outer side of the leg, and one or two *articular* branches running with the external articular arteries, should be searched for and isolated. The *communicans peronei* or *fibularis*, the largest cutaneous branch, arising near the head of the fibula, passes downward and inward to join the communicans poplitei, thus forming the external saphenous nerve.

The Popliteal Vein.—The **origin** of this vein is by the convergence of the accompanying veins of the anterior and posterior tibial arteries at the lower border of the popliteus muscle. Passing approximately through the centre of the space, it leaves it through the opening in the adductor magnus to become the femoral vein. Displacing the superficially lying internal popliteal nerve, the vein should be carefully denuded, when its close association with the somewhat more deeply placed popliteal artery will be noted. A popliteal lymph-node will be found usually in relation with the vein near the middle of the space (Fig. 88); three or four other less conspicuous and less constant nodes are found along the course of the vessels. The **tributaries** of the popliteal vein are the short *saphenous vein* (p. 257) and *veins* corresponding to the branches of the popliteal artery.

The popliteal vein is noteworthy for the thickness of its walls, by reason of which it is seldom torn in accident or injury unless the violence is sufficient also to lacerate the popliteal artery.

The Popliteal Artery.—This vessel **arises** as the continuation of the femoral artery, entering the popliteal space through the adductor magnus and **terminating** at the lower border of the popliteus muscle by dividing into the anterior and posterior tibial arteries. Its course will be indicated by a **surface line** passing through the middle of the popliteal space inclining a little to the inner side above. The branches of the popliteal artery, some of which will have been encountered in dissecting the popliteal vein, should be looked for during the progress of the dissection of the artery itself, which latter should be begun at its beginning at the upper part of the space, the popliteal vein and the internal popliteal nerve being pulled aside to facilitate exposure of the vessel. In denuding the artery, the dissector should look for the **articular branch** of the obturator nerve (p. 220) which lies upon the artery; in most cases it is difficult to discover.

The Branches of the Popliteal Artery.—The first **branches** encountered are the upper **muscular branches,** after which a few **cutaneous branches** will be met with; the **superior internal** and **external articular** branches arise from the inner and outer aspects respectively of the artery a few inches above the knee-joint. Each one of these should be traced in its course transversely outward or inward beneath the outer and inner hamstring muscles respectively—the inner one piercing the adductor magnus—to the corresponding aspect of the knee. The **azygos** (unpaired) **articular** branch, arising usually from the deep aspect of the vessel opposite the middle of the space, pierces the posterior ligament of the knee-joint in company with a branch of the internal popliteal nerve; this vessel may be overlooked or cut without the exercise of care in slightly displacing the popliteal artery in order to expose it. Farther along, the **inferior internal** and **external articular** branches arise, the *internal artery* passing under the inner head of the gastrocnemius to get to the inner aspect of the knee and then beneath the internal lateral ligament (Fig. 146); the *external articular* branch should be followed outwardly beneath the outer head of the gastrocnemius and the plantaris and, as it curves around to the outer side of the knee, beneath the long external lateral ligament. The two **sural branches,** the large (lower) muscular branches passing to the respective heads of the gastrocnemius muscle, should be followed to their terminations.

The Relations of the Popliteal Artery.—Having denuded the popliteal artery and its branches, the vein and the internal popliteal nerve, as well as the muscular and tendinous boundaries of the space, may be replaced as nearly as possible in position, that the relations of the structures to each other may be studied (Fig. 88). These relations have been indicated above, but the student should note particularly the relations of the popliteal artery. The popliteal vein, it will be seen, lies upon the outer side of the artery above, crossing it superficially to get to its inner

side in the lower part of the space. Comparing this relation with the relations of the femoral vein to the femoral artery it will be seen that from the origin of the femoral artery at Poupart's ligament to the termination of the popliteal artery in the lower part of the popliteal space, the vein changes its relation completely twice; thus, while at Poupart's ligament it is internal to the artery, it gradually gets behind it and then to its outer side, which relation is held in the upper part of the space, after which the vein again gradually gets behind the artery and back to its inner side. The relation of the internal popliteal nerve is the same as that of the vein, that is, it is upon the outer side above and then, crossing superficially, upon the inner side below, the nerve being superficial to

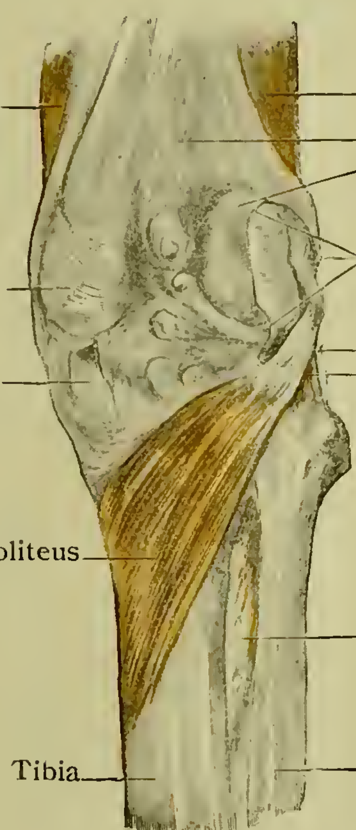

Fig. 89.—Deep dissection of leg, showing popliteus muscle.

both vein and artery. The anterior relations of the artery will be studied after the completion of the dissection of the floor of the popliteal space.

The **floor of the space** is constituted in its upper third by the popliteal surface of the femur (Fig. 89), in its middle third by the posterior ligament of the knee-joint, and in the lower third by the popliteus muscle covered by the popliteal fascia. These parts of the floor should be cleared of connective tissue and fat. In dissecting the middle third, note the expansion given off from the tendon of the semimembranosus muscle, which passes upward and outward to the outer condyle, blending with the posterior ligament of the joint (Fig. 134); note also the perforation of this ligament by the azygos articular artery and the corresponding articular branch of the internal popliteal nerve and by the articular branch of the obturator nerve. In dissecting the lower third of the floor,

that is, the popliteal fascia, note a similar expansion from the tendon of the semimembranosus which blends with this fascia.

The Popliteus Muscle (Fig. 89).—**Origin,** by a tendon from an impression on the outer surface of the outer condyle of the femur, the tendon passing through the capsule of the knee-joint (Fig. 89) and expanding into a flat quadrilateral muscle which is **inserted** into the inner two-thirds of the posterior surface of the tibia above the oblique line; **nerve-supply,** the internal popliteal nerve (fifth lumbar, and first sacral); **action,** flexion and internal rotation of the leg.

This muscle, as previously noted, constitutes the floor of the lower third of the popliteal space and is covered by a dense fascia (page 264), which latter should be removed to expose the muscle (Fig. 89). In doing this, the nerve to the popliteus should be guarded against injury. The tendon of origin should be inspected and its relation to the overlying external lateral ligaments noted, as well as its relation to the knee-joint capsule (Fig. 149). A **bursa** intervenes between the tendon and the outer condyle of the femur.

The **nerve to the popliteus** should now be followed around the lower border of the muscle to its deep surface, the muscle being cut for this purpose. Besides supplying the muscle, the nerve sends filaments to the tibio-fibular articulation, to the tibia and to the interosseous membrane.

The deep relations then of the popliteal artery are the several parts of the floor of the space above designated. The lower part of the popliteal artery would, therefore, correspond to the upper part of the interosseous space between the tibia and the fibula.

The relation of the popliteal artery to the knee-joint renders it especially liable to aneurism, owing to the frequent alterations in pressure due to the flexion of the knee-joint and owing also to the fact that this artery is not supported by closely related muscles but is surrounded by a packing of rather loose tissue. Its close proximity to the lower part of the shaft of the femur explains its liability to injury, as laceration, in fractures of the lower part of this bone, while its relation to the upper part of the interosseous space of the leg above noted, renders it vulnerable in case of injury by a penetrating instrument, such as a dagger, applied to the front of the leg below the knee. By reason of its close relation to the joint it is also subject to injury in dislocation at this joint.

DISSECTION OF THE POSTERIOR ASPECT OF THE THIGH.

A median longitudinal incision having been made, the skin should be reflected, leaving the superficial fascia in position.

The **superficial fascia** presents no features of special interest save the cutaneous filaments of the small sciatic nerve (Fig. 81), with a few branches along the outer border from the external cutaneous nerve. If difficulty is experienced in detecting the former, they may be disregarded for the present, the superficial fascia, dissected from a median

incision, being removed only to the extent of exposing the middle third of the surface, when the nerves may be found as they emerge through the deep fascia.

The Deep Fascia.—The deep fascia of this region is merely a part of the deep fascia of the thigh, the **fascia lata,** and is therefore continuous above and below with those parts of this membrane already encountered in the gluteal and popliteal regions respectively. The lateral thickened band of this fascia, the **ilio-tibial** band, the insertion of a portion of the gluteus maximus into its upper part (Fig. 82) and the attachment of the fascia to the bony prominences about the knee are noteworthy.

The **small sciatic nerve,** the origin and termination of which have been noted (pp. 171 and 176), will be found upon the surface of the fascia lata at least in the lower third of the thigh; occasionally it becomes superficial at the gluteo-femoral fold; its cutaneous branches to the gluteal region and the upper part of the thigh (Fig. 81) should be worked out and the cutaneous branches to the perinæum, and the inferior pudendal nerve, which curves inward and upward below the tuberosity of the ischium toward the perineal region, should also be followed. In those cases where the upper part of the nerve lies beneath the deep fascia, the latter must necessarily be first reflected from a median longitudinal incision.

In reflecting the deep fascia, the dissector should exert traction upon the flaps and make light cuts with the knife close to its deep surface; the soft loose tissue between the fascia and the muscles being easily dissociated. The muscles and other structures thus exposed (Fig. 83) should be disturbed in their relations as little as possible, the connective tissue covering the exposed surfaces of the muscles being removed with caution as regards small nerves—muscular branches to the muscles in question—in order that the undisturbed relations of the structures may be better appreciated.

The Biceps Cruris or Femoris.—**Origin,** the *long head,* from the lower and inner part of the tuberosity of the ischium in common with the semitendinosus; the *short head,* from the lower two-thirds of the linea aspera and the upper part of its outer prolongation below; **insertion,** into the head of the fibula and by a small slip into the outer tuberosity of the tibia, the tendon embracing the long external lateral ligament of the knee-joint; **nerve-supply,** the great sciatic nerve (fifth lumbar and first three sacral nerves); **action,** flexion of the leg upon the thigh and extension of the trunk upon the thigh; secondarily, external rotation (Fig. 83).

The dissector should first denude the long head of this muscle beginning at its attachment to the tuberosity of the ischium and following it in its course obliquely across the thigh to its point of junction with the short head. The muscular branch which supplies the long head should

be looked for entering the outer side or possibly the deep surface of the mass. The short head of the muscle may then be dissected, its nerve of supply being found on its inner aspect and rather high up. In following the tendon to its insertion regard must be had for the external popliteal or peroneal nerve which lies close to the tendon on its inner side. A **bursa** is interposed between the tendon and the long external lateral ligament of the knee-joint (Fig. 147).

THE SEMITENDINOSUS.—**Origin,** the inner and back part of the tuberosity of the ischium in common with the long head of the biceps; **insertion,** the upper part of the inner surface of the shaft of the tibia in company with the sartorius and the gracilis; **nerve=supply,** the great sciatic nerve (fifth lumbar and first two sacral nerves); **action,** flexion of the leg upon the thigh and extension of the trunk upon the thigh; secondarily, internal rotation (Fig. 83).

Begin denuding this muscle at its origin looking for its nerve of supply on the outer side of the muscle (Fig. 91), carrying the denudation down to the long slender tendon which begins a little below the middle of the thigh. A bursa, the **bursa anserina,** is placed between the tendon of this muscle, with that of the gracilis, and the tibia.

THE SEMIMEMBRANOSUS.—**Origin,** from the upper and outer portion of the tuberosity of the ischium; **insertion,** the transverse groove on the posterior aspect of the inner tuberosity of the tibia; **nerve=supply,** the great sciatic nerve (fourth and fifth lumbar and first sacral); **action,** flexion and to some extent internal rotation of the leg upon the thigh as well as extension of the trunk upon the thigh (Fig. 90).

The cleaning of this muscle should be begun at its origin, the semitendinosus being displaced and the dissector noting the broad aponeurosis of origin on the deep surface of the muscle and carrying the denudation down to the termination of the tendon. When the latter point is reached note should be made of an expansion given from the tendon, which is the continuation of the aponeurosis on the superficial surface of the muscle, to the deep fascia of the leg, and of a second expansion passing upward and outward to blend with the posterior ligament of the knee-joint (Fig. 90). The tendon of insertion is separated from the inner head of the gastrocnemius by a **bursa** and from the inner condyle of the tibia by a second **bursa** (Fig. 146).

The **great sciatic nerve** (page 172) should now be followed from the gluteo-femoral fold along the median aspect of the thigh to the apex of the popliteal space, the long head of the biceps being elevated and displaced where the nerve passes beneath this muscle. The division of the nerve into its terminal branches, the internal and external popliteal nerves, may take place at any point between its origin from the sacral plexus and the apex of the popliteal space. Muscular branches to the two heads of the biceps, the semitendinosus and the semimembranosus,

already encountered, should be isolated as well as the muscular branch or branches to the adductor magnus (Fig. 91). The **comes nervi ischiadici** or accompanying artery of the sciatic nerve, a branch of the sciatic

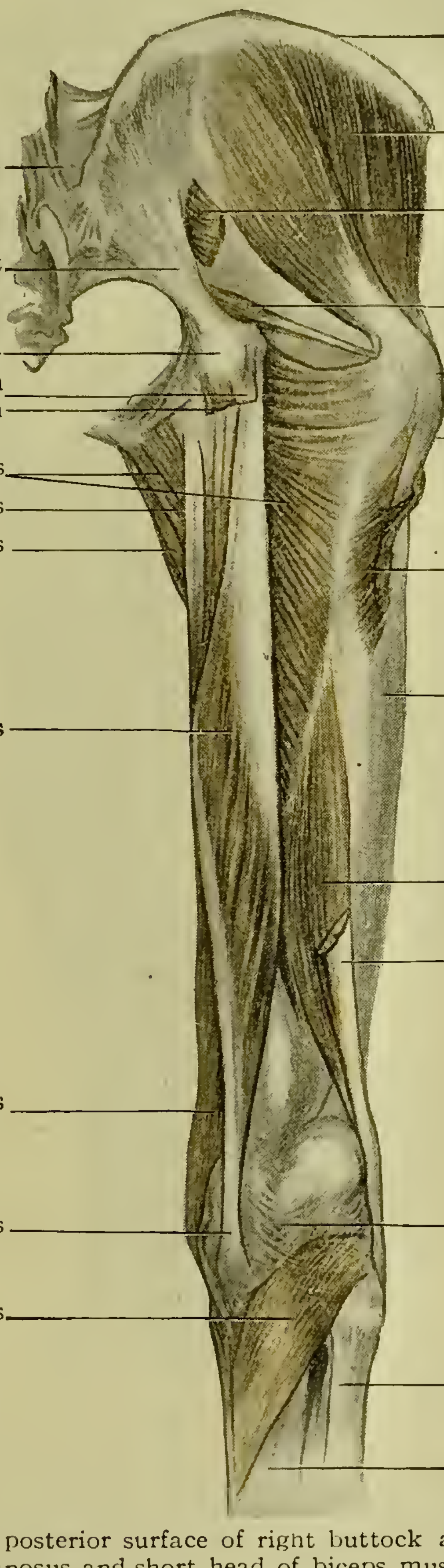

FIG. 90.—Deep dissection of posterior surface of right buttock and thigh, exposing semimembranosus and short head of biceps muscles.

artery, usually a very small vessel, may be found within the substance of the nerve or upon its surface and, in some cases, may be traced as far as the popliteal space.

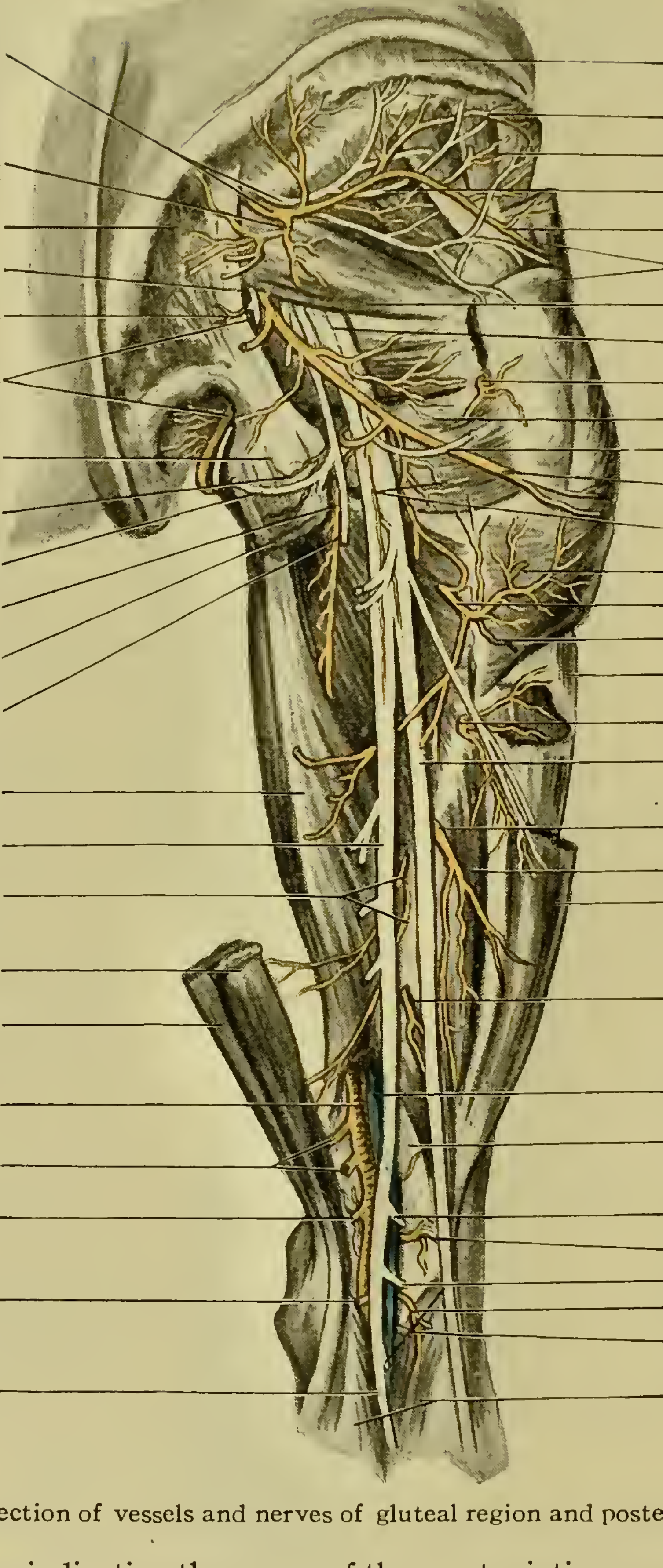

Fig. 91.—Deep dissection of vessels and nerves of gluteal region and posterior aspect of thigh.

The surface line indicating the course of the great sciatic nerve is one drawn from a point midway between the tuberosity of the ischium and the great trochanter of the femur to the middle of the popliteal space. **Stretching of this nerve** is sometimes done for persistent neuralgia. This may be effected by the *non-operative method*, that is, by flexion of the thigh with the leg extended to stretch the nerve over the convexity of the lower part of the gluteal region and the hip-joint; or by the *operative method*, which consists in exposing the nerve by an incision in the line of its course and forcibly elevating the nerve to the extent of slightly raising the leg from the operating table.

The posterior surface of the adductor magnus should now be cleaned, the foregoing muscles being displaced, and the terminations of the perforating arteries from the profunda femoris (page 205) should be worked

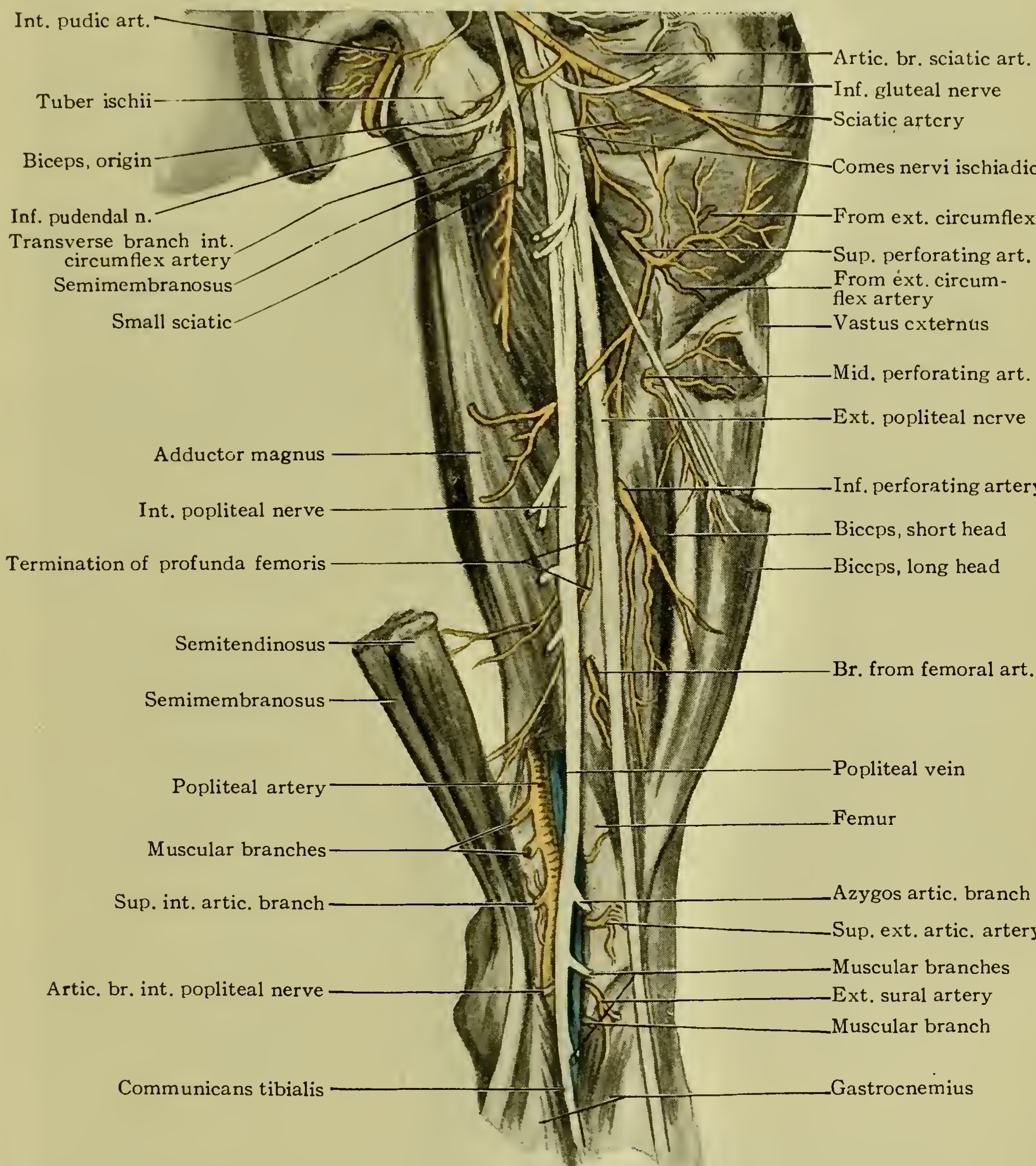

FIG. 92.—Deep dissection of vessels and nerves of posterior aspect of thigh and of popliteal space.

out (Fig. 92). At the lower part of the adductor magnus the aperture in this muscle for the femoral artery and vein should be noted, as should also the extensive insertion of the muscle, including as it does the entire length of the linea aspera with its outer prolongation above and its inner prolongation below.

The **crucial anastomosis** (Fig. 92) previously mentioned may now be more fully studied, the transverse or descending branch of the internal circumflex artery being found emerging between the lower border of

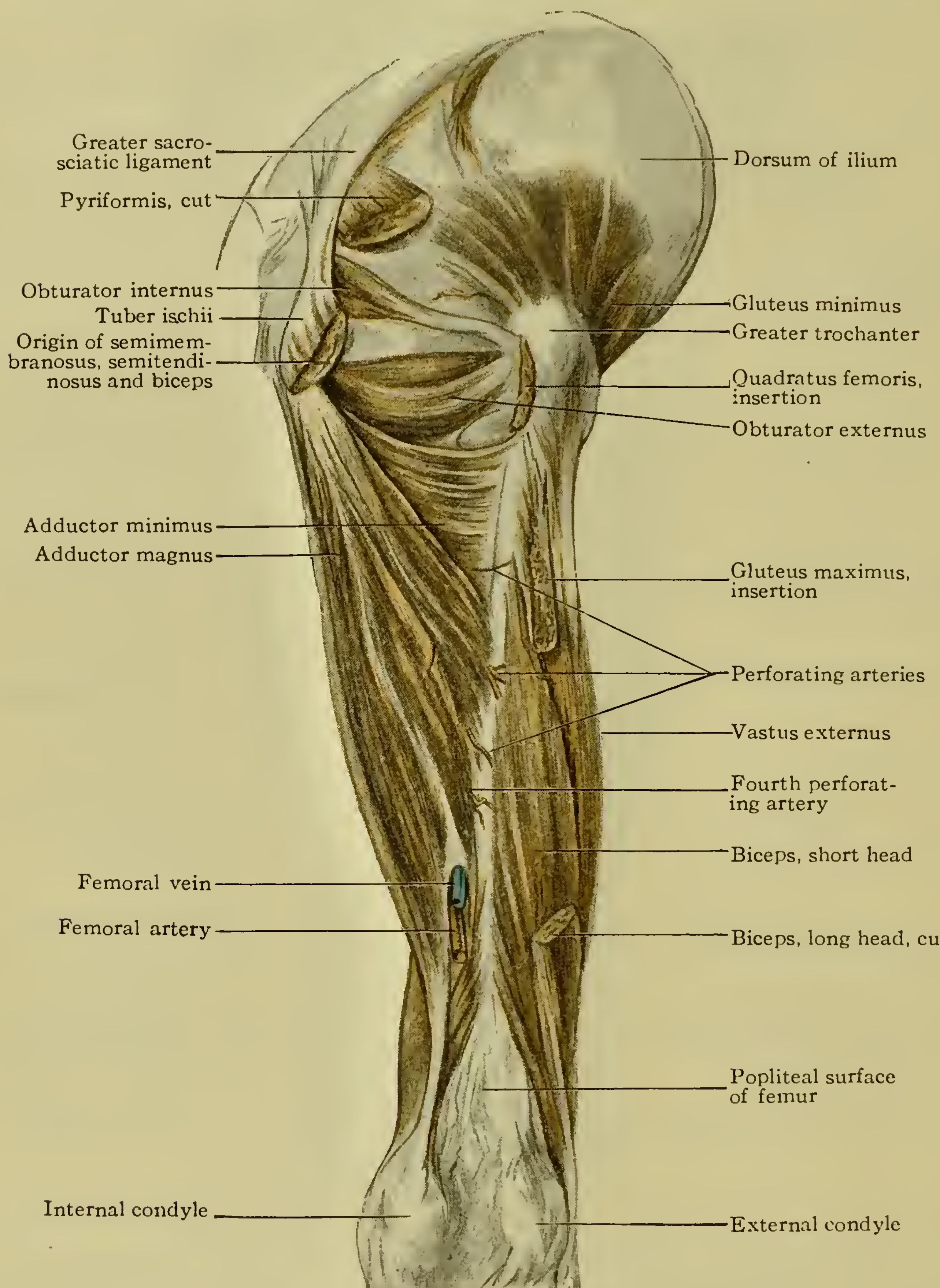

Fig. 93.—Deep dissection of posterior surface of right thigh.

the quadratus and the adductor magnus to anastomose with the anastomotica of the sciatic, the external circumflex and the first perforating branch of the profunda femoris (Fig. 92).

The Posterior Aspect of the Hip-Joint.—Although the hip-joint cannot be dissected until the completion of the work on the anterior surface of the thigh, it is necessary to study its posterior aspect at this stage of the work. To expose fully this part of the joint it is necessary that all the muscles attached to the great trochanter, including the gluteus minimus, should be detached from that prominence. It is important, however, that the several tendons of insertion should be reunited by sutures before the body is turned, in order to preserve the proper relations of parts. When the obturator internus and the two gemelli are detached from the great trochanter and reflected, the nerve to the quadratus femóris, which usually gives to the hip-joint the branch or branches reaching it from the sacral plexus, will be found between these muscles and the capsule (Fig. 85). Articular filaments from the great sciatic nerve may be found in the same region, as may also articular branches of the ascending trunk of the internal circumflex artery and an articular branch from the anastomotica of the sciatic (Fig. 84). Upon reflecting the distal portions of the obturator externus and quadratus femoris, the ascending branch of the internal circumflex will be seen coursing toward the digital fossa (Fig. 78). This exposes the posterior aspect of the hip-joint **capsule** which should be cleared of any loose cellular tissue and of fat, in doing which the nerves and blood-vessels mentioned should be identified and isolated.

Note should be made of the fact that the capsular ligament, attached above to the acetabulum, is attached below to the neck of the femur along a line a half-inch above the posterior inter-trochanteric line. The **ischio=femoral ligament,** a localized thickening of the capsular ligament, is detected as a band passing from the posterior part of the acetabulum downward and outward to the neck of the femur.

This thickened band should be carefully dissected, that its extent may be appreciated. In spite of the presence of the ischio-femoral band, the lower posterior portion of the capsular ligament is the weakest part of that membrane, a defect compensated for in a measure by the close relation of the external rotator muscles of the thigh which have just been removed.

Owing to the line of attachment of the capsular ligament as noted above, a **fracture** of the neck of the femur may be either within the limits of the capsule, *intracapsular fracture*, or beyond its line of attachment, *extracapsular fracture.* This distinction could only apply, however, to the situation of the line of fracture on the posterior surface of the neck, since the anterior attachment of the capsule is such as to include the entire anterior surface of the neck of the bone (p. 230). No fracture of the neck of the femur could therefore be wholly extracapsular.

The weakness of the lower posterior portion of the capsule affords an explanation, in part, of the fact that in all the regular dislocations at the hip-joint the head of the femur leaves the acetabulum through a rent in this part of the capsular ligament.

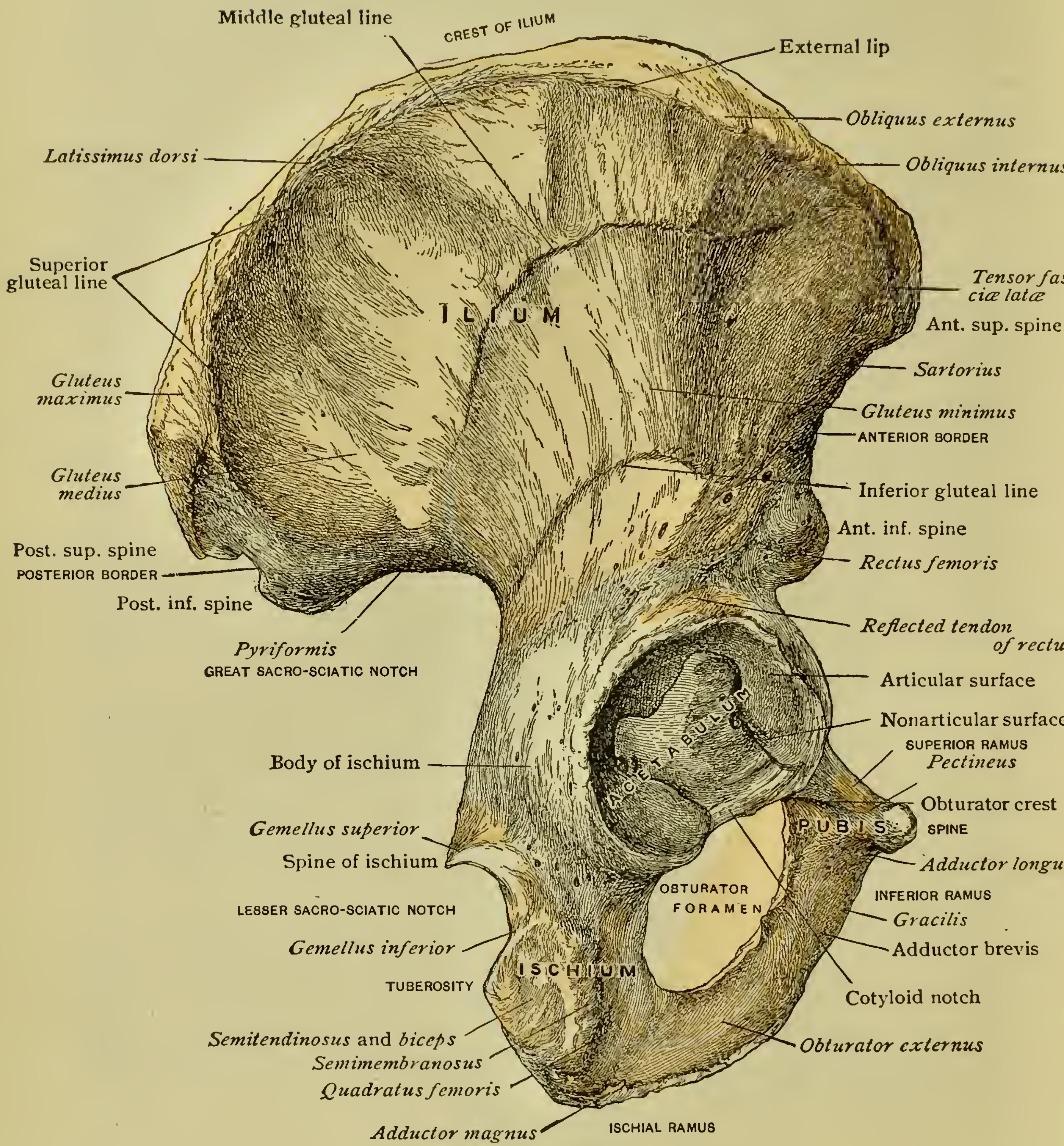

FIG. 94.—Right innominate bone, outer aspect.

THE ANTERIOR SURFACE OF THE THIGH.

Referring to the **bony pelvis** (Fig. 94) the student should identify the *pubic symphysis*, the *angle* of the pubis, the *crest*, passing outward from the latter and terminating in the *pubic spine*, the *body of the pubis* with its *vertical* and *horizontal rami* and their relation to the *obturator*

foramen, and the *pectineal line* and *pectineal eminence*. The *anterior superior* and *inferior spines* of the *ilium* should also be noted, as well as the *acetabulum* and its relation to the three parts of the os innominatum.

The anterior aspect of the **femur** (Fig. 95), presenting above the

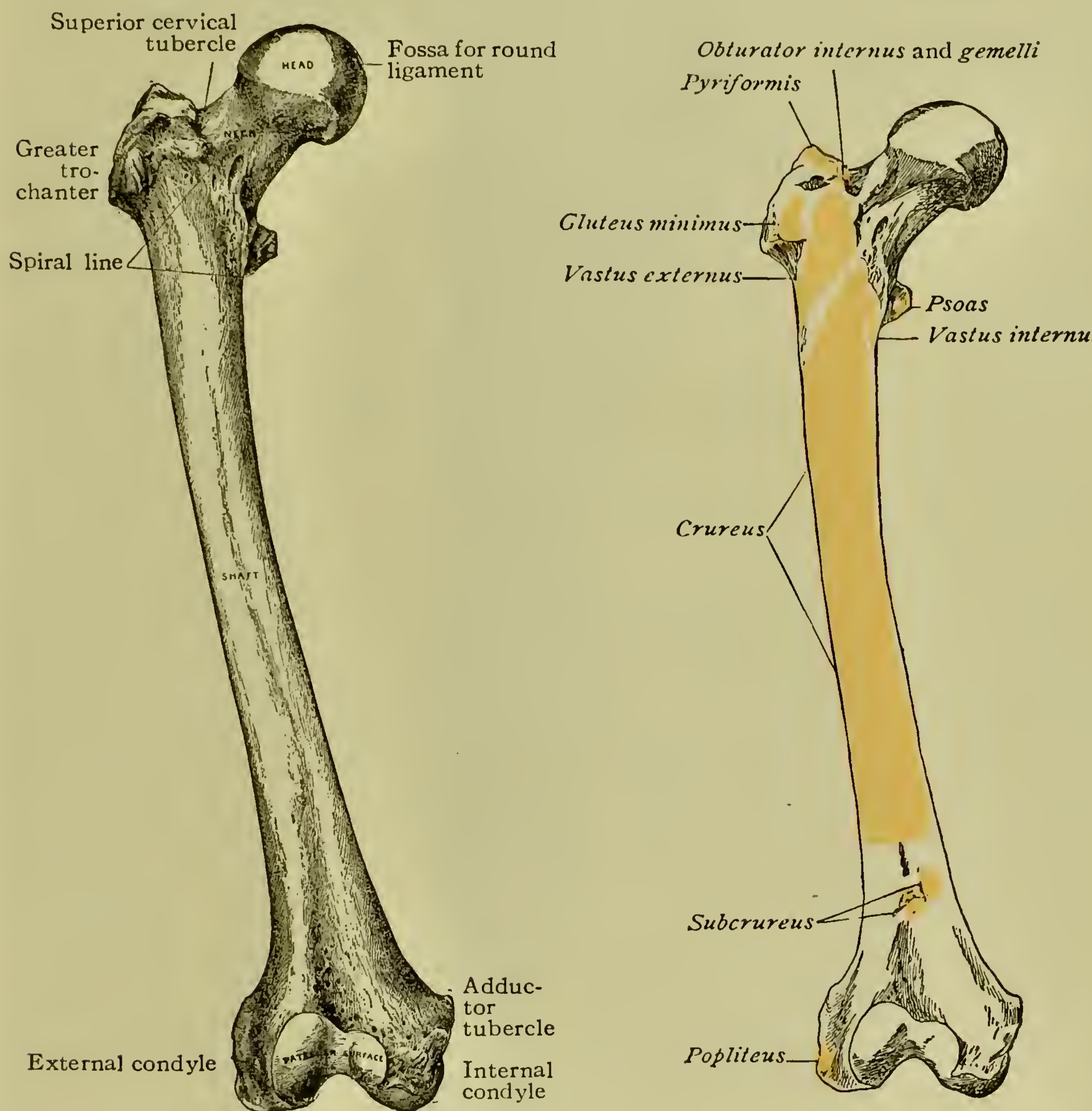

Fig. 95.—Right femur from before. The outline figure shows the areas of muscular attachment.

great trochanter, the *neck* and the *spiral line*, and below, the *inner* and *outer condyles* with their *articular facets* for the patella and the tuberosities of the tibia, the inner condyle showing at its upper inner aspect the *adductor tubercle*, and the outer condyle on its outer surface the rough *impression* and *groove* for the popliteus muscle, should be briefly reviewed, the smooth rounded *shaft* not being overlooked.

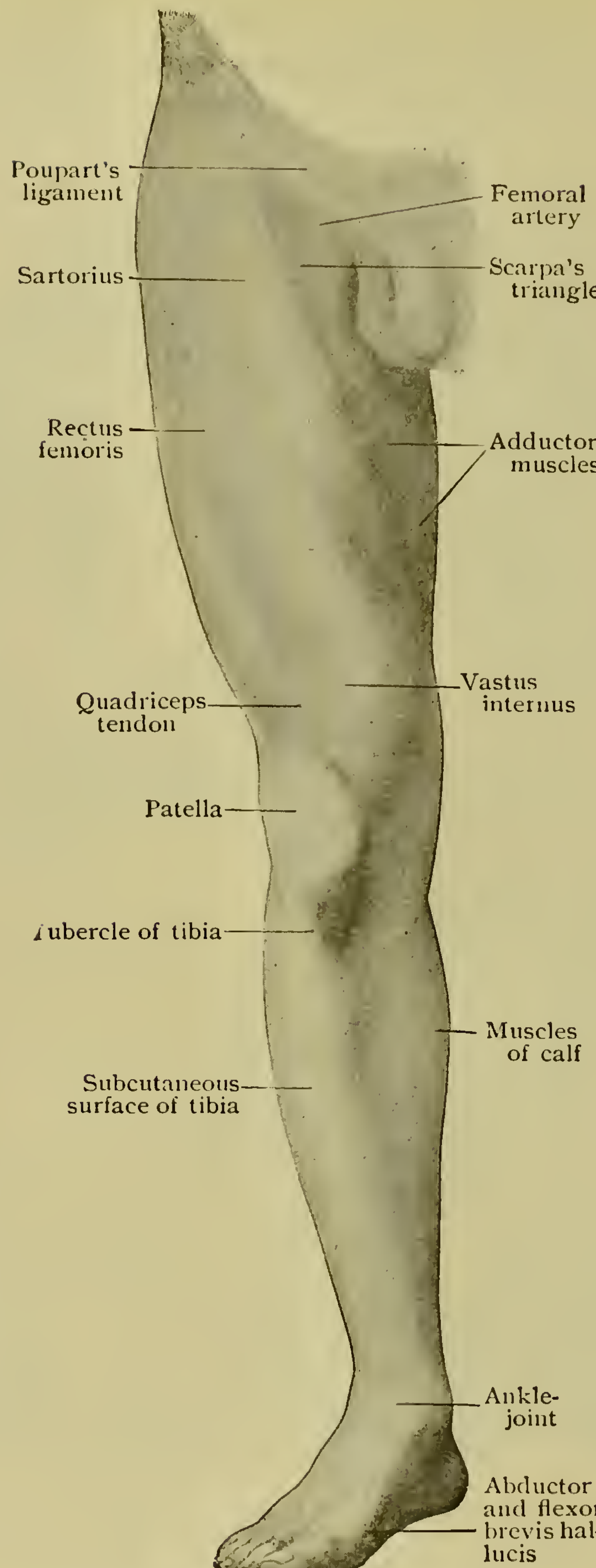

FIG. 96.—Antero-median surface of right leg, showing modelling on living subject.

THE SURFACE ANATOMY.

The **anterior superior spine** of the ilium may be easily recognized, and about four inches below and behind this prominence will be felt the prominence of the **great trochanter** of the femur (Fig. 96). From

the anterior superior spine the line of Poupart's ligament will be indicated by a crease, the **fold of the groin,** extending downward and inward to the inner attachment of Poupart's ligament, the spine of the pubis. Below and above Poupart's ligament is a chain of lymph-nodes which are usually not distinctly palpable when of normal size, but when enlarged are easily recognized. A half-inch below Poupart's ligament and parallel with it is a secondary crease, **Holden's line,** which passes across the front of the hip-joint capsule. Below Poupart's ligament, occupying approximately the upper third or fourth of the thigh, is a depressed **triangular area,** the apex of the triangle pointing downward, the base formed by Poupart's ligament, corresponding to the position of Scarpa's triangle (Fig. 96). The femoral vessels passing through this triangle from the middle of the base to the apex are palpable, the pulsations of the femoral artery, the more external of the two vessels, being easily felt. It is in this triangle at any point within an inch and a half of Poupart's ligament and upon the inner side of the femoral vein that a femoral hernia makes its appearance. The ridge which constitutes the outer boundary of this triangular depression is formed by the sartorius muscle, while the inner boundary of the depression is the ridge formed by the adductor longus muscle. By abducting the thigh the tendon of the adductor longus is made tense and may be easily recognized and followed up to the origin of the muscle just in front of the spine of the pubis. The internal or long saphenous vein is visible usually through the skin as a bluish marking extending from a point about an inch and a half below the middle of Poupart's ligament downward and inward to a point behind the inner condyle of the femur. The large fleshy mass on the front of the thigh is due to the quadriceps extensor muscle, the insertion of which into the patella or knee-cap is recognizable in the form of a thick, tense tendon which is attached to the upper border of this bone.

The tenseness of the **ilio-tibial band** (Fig. 82) on the outer surface of the thigh is plainly recognizable in the living subject in the standing position, while the large mass of the adductor group of muscles constitutes a conspicuous feature of the inner surface of the thigh.

THE DISSECTION OF THE REGION OF SCARPA'S TRIANGLE.

An incision along the line of Poupart's ligament and a vertical incision from the middle of the latter ligament downward to about the junction of the upper and middle thirds of the thigh should be made, to which may be added a transverse incision at the latter point (Fig. 97). The skin-flaps should be carefully reflected from the longitudinal incision inward and outward respectively, the dissection being limited at this stage to the upper third of the thigh, the lower part being protected from drying by appropriate means.

The Superficial Fascia.—The superficial fascia here, as elsewhere, is seen to contain a considerable amount of fat in its meshes. In this region of the thigh it is separable into a superficial and a deep layer.

The **superficial layer** should be dissected from a median longitudinal incision as in the case of the skin. Care must be exercised in order to avoid taking up the deep layer with the superficial layer. As a guide to the recognition of the superficial layer, the presence of superficial veins, and especially of the internal saphenous vein, and of some small arteries will be an aid, as will also be the presence of the greater portion of the fat within the superficial layer.

The Superficial Vessels.—The **saphenous opening** of the fascia lata or deep fascia should be located in order to aid in the recognition and identification of the vessels of the superficial fascia (Fig. 100). The lower

Fig. 97.—Cadaver showing lines of incision.

margin of this aperture is about an inch and a half below a point slightly to the inner side of the middle of Poupart's ligament. It will be impossible to reflect the two flaps of this fascia as indicated without interfering with the small vessels which ramify within it. Therefore, let the dissector first dissect from the median incision toward the inner side of the thigh, keeping watch for the **internal saphenous vein,** which should be found in a line extending from the lower margin of the saphenous opening to a point behind the inner condyle of the femur. As soon as the vein is discovered it is easily avoided. Above, and to the inner side of the saphenous opening, the **superficial external pudic artery** and **vein** will be found, and almost vertically upward from the opening the **superficial epigastric artery** and **vein** (Fig. 98). The **superficial circumflex iliac artery** and **vein** will be encountered just below the outer part of Poupart's ligament, having perforated the deep fascia above and to the outer side of the saphenous opening. Another of the branches of the

femoral artery is the **deep external pudic,** which becomes superficial upon perforating the deep fascia at the inner and upper limit of the thigh, near the pubic region. Bearing in mind the situation of these structures, the dissector will carefully raise the superficial layer of the superficial fascia first inward from the median incision and then outward,

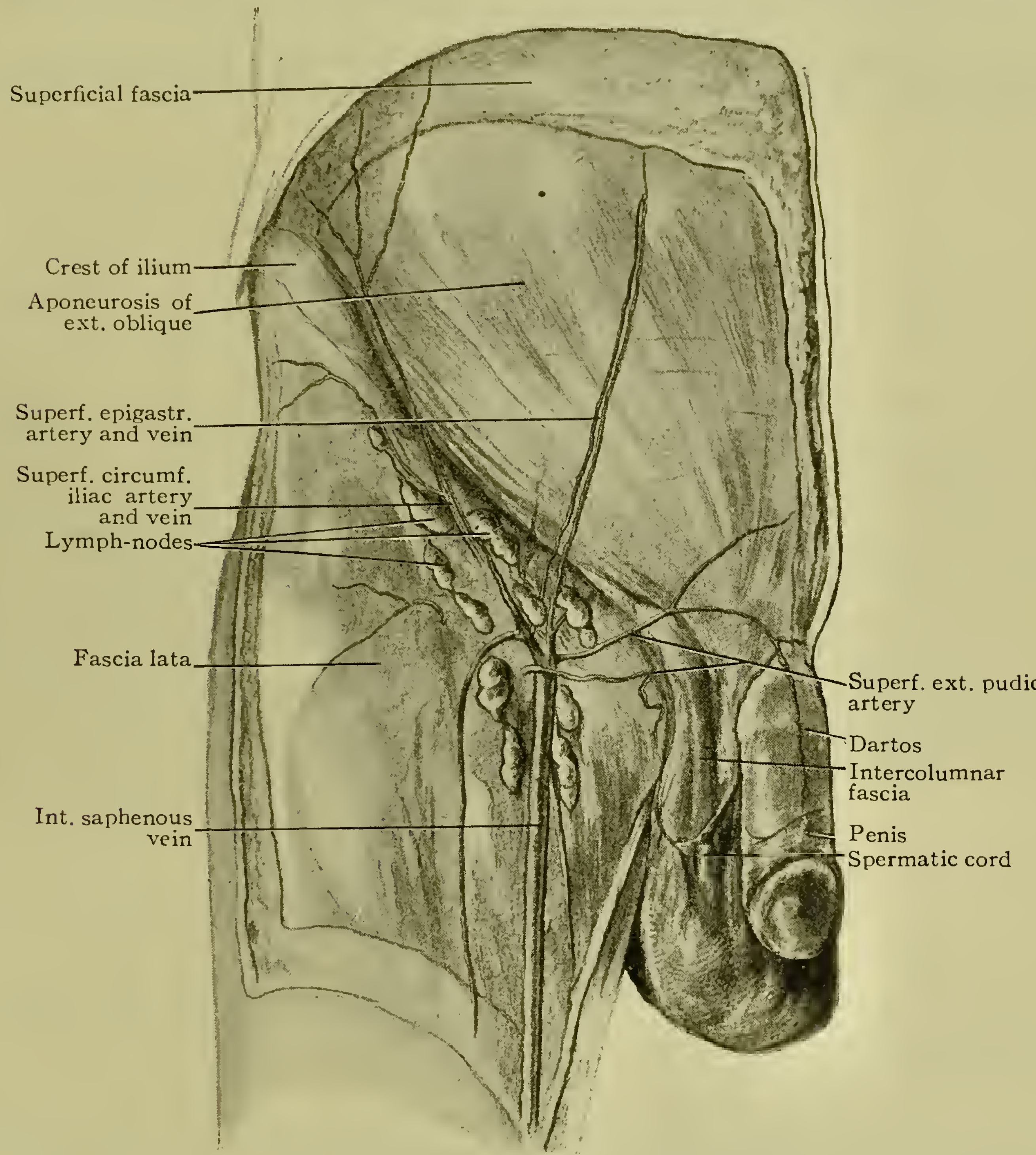

FIG. 98.—Superficial dissection of inguinal region.

when he will be able to demonstrate that this layer is continuous without interruption with the fascia of Camper or the superficial layer of the superficial fascia of the abdomen.

The **superficial inguinal lymph-nodes,** ten to fifteen in number, are now exposed (Fig. 98). The *vertical group* of these nodes is disposed about the saphenous opening and receives the superficial lymph-vessels, chiefly, which accompany the internal saphenous vein; the *horizontal*

nodes are arranged along Poupart's ligament and receive lymph-vessels from the infra-umbilical region of the abdominal wall, from the gluteal region and from the external genitalia.

Enlargement of these nodes occurs in case of infective inflammation of the regions drained by their tributary lymph-vessels—such, for example, as infected ulcers, chancre, chancroid, and tuberculous and carcinomatous affections of the external genitals.

The **deep layer of the superficial fascia,** now exposed, is a relatively thin lamina reposing upon the deep fascia. For the most part the super-

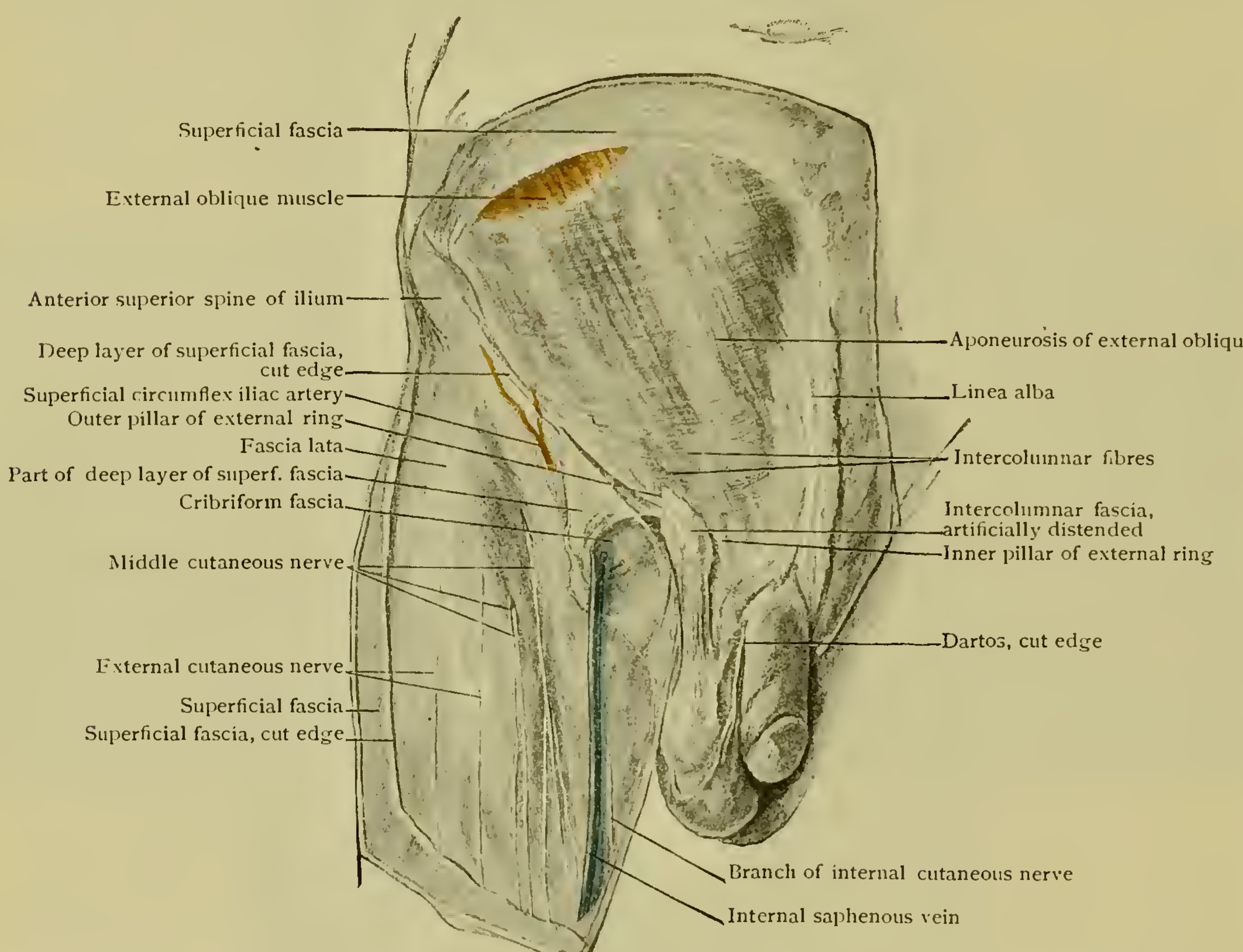

FIG. 99.—Superficial dissection of inguinal region; spermatic cord is seen issuing from external abdominal ring; intercolumnar fascia has been artificially distended by injection of fluid; saphenous opening is closed by cribriform fascia.

ficial arteries and veins mentioned above lie upon this deeper layer. The **cribriform fascia** (Fig. 99) is that part of this layer which covers the saphenous opening of the fascia lata. The tip of the finger passed downward and outward from the spine of the pubis, the thigh being in abduction, will detect the outer curved margin of the aperture and its continuity with the lower margin. The superficial epigastric and superficial external pudic arteries emerge from the femoral artery through the cribriform fascia, while the corresponding veins and the internal saphenous vein pass downward through it to terminate in the femoral vein, accompanied by some lymph-vessels and nerve filaments. Making two

longitudinal incisions through the deep layer of the superficial fascia, one several inches to the inner side of the saphenous opening, and one several inches to its outer side, and a transverse incision several inches below it, the fascia should be dissected up as far as the inner and outer margins of the opening respectively, observing not to disturb the attachment of this fascia to the fascia lata just below Poupart's ligament.

The dissector will now have demonstrated the continuity of the superficial layer of the superficial fascia of the thigh with the corresponding

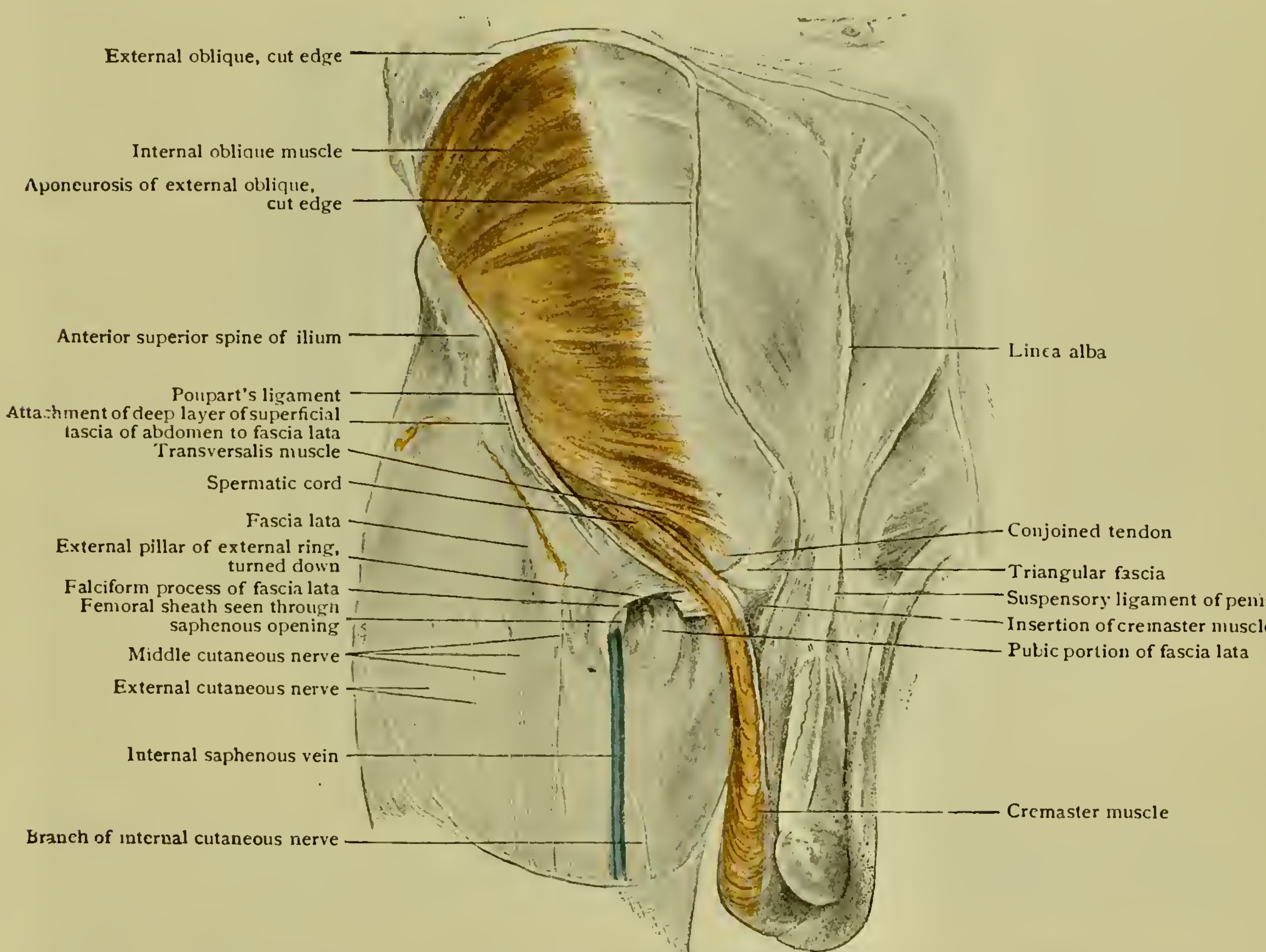

FIG. 100.—Deeper dissection in which external oblique has been partially removed, exposing spermatic cord lying in inguinal canal; cribriform fascia removed to show saphenous opening.

layer or Camper's fascia of the abdomen, and also the interruption in the deep layer of the superficial fascia where that layer is bound down to the fascia lata in a line parallel with and about a half-inch below Poupart's ligament; as well as the adhesion of the deep layer to the margins of the saphenous opening (Fig. 99).

The Superficial Nerves.—The **external cutaneous nerve,** a branch of the lumbar plexus arising from the second and third lumbar nerves, traversing the iliac fossa and passing under the outer extremity of Poupart's ligament to enter the thigh (Fig. 105), will usually be found piercing

the fascia lata about four inches below the anterior superior spine of the ilium (Fig. 99). From this point the nerve should be traced as far downward as the transverse skin incision.

The **middle cutaneous nerve,** a branch of the anterior division of the anterior crural nerve, perforates the fascia lata at a point from four to six inches below Poupart's ligament (Fig. 100). It is quite frequently represented by two trunks, which continue down the middle of the front of the thigh and which should be traced to the lower limit of the dissection.

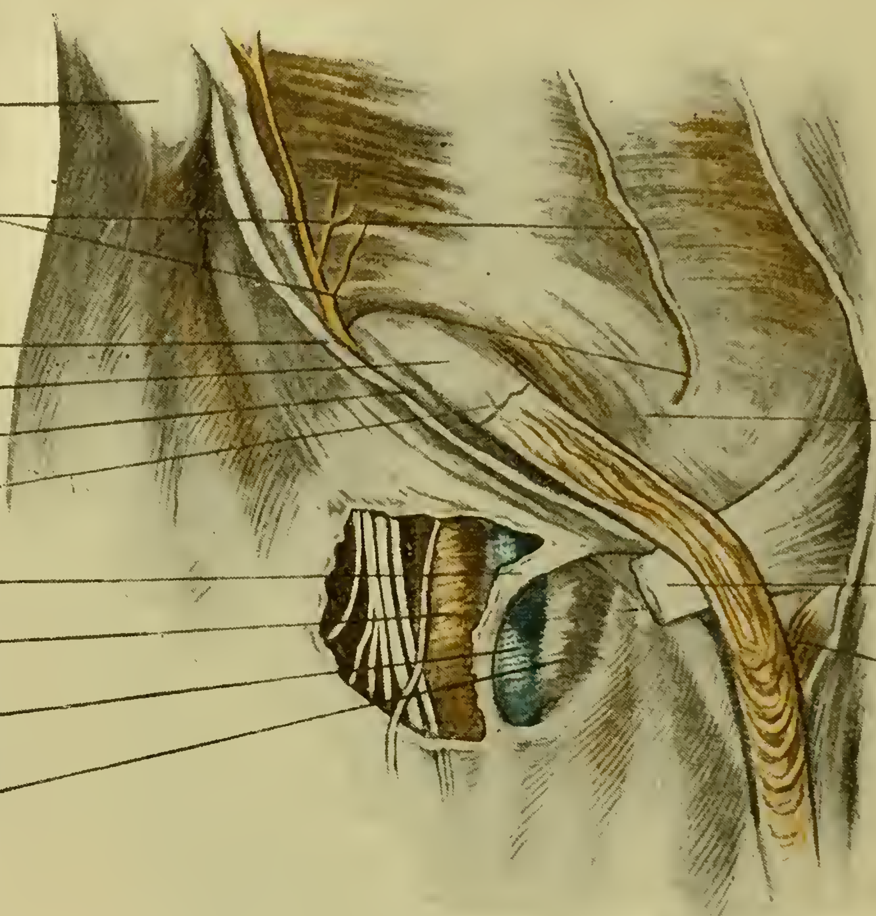

FIG. 101.—Internal oblique muscle has been partially removed, showing fibres of transversalis arching over spermatic cord to reach conjoined tendon; fascia lata has been opened to expose femoral vessels lying within sheath; femoral canal has been artificially distended.

The **internal cutaneous nerve,** also a branch of the anterior division of the anterior crural, may pierce the fascia lata near the inner side of the front of the thigh at a point six inches or more below Poupart's ligament. When found, it should be traced downward to the lower limit of the dissection.

The **crural branch** of the genito-crural nerve enters the thigh within the sheath of the femoral artery, lying immediately over the artery, and may pierce the fascia lata immediately above the outer margin of the saphenous opening or somewhat more externally and farther down (Fig. 105). It is sometimes difficult to discover. It is distributed to the skin of the upper and inner part of the thigh. Its course within the sheath of the vessels will be seen at a later stage of the work.

The Fascia Lata.—After complete isolation of the vessels and nerves mentioned above, the remnants of the superficial fascia should be removed to expose the fascia lata or deep fascia of the thigh. This will be seen as a whole (Fig. 106) only when the skin and superficial fascia shall have been removed from the entire thigh; hence the only part of it that concerns us at present is that which falls within the limits of this dissection. The **iliac portion** of the fascia lata extends from the spine of the ilium to the spine of the pubes and is attached to Poupart's ligament

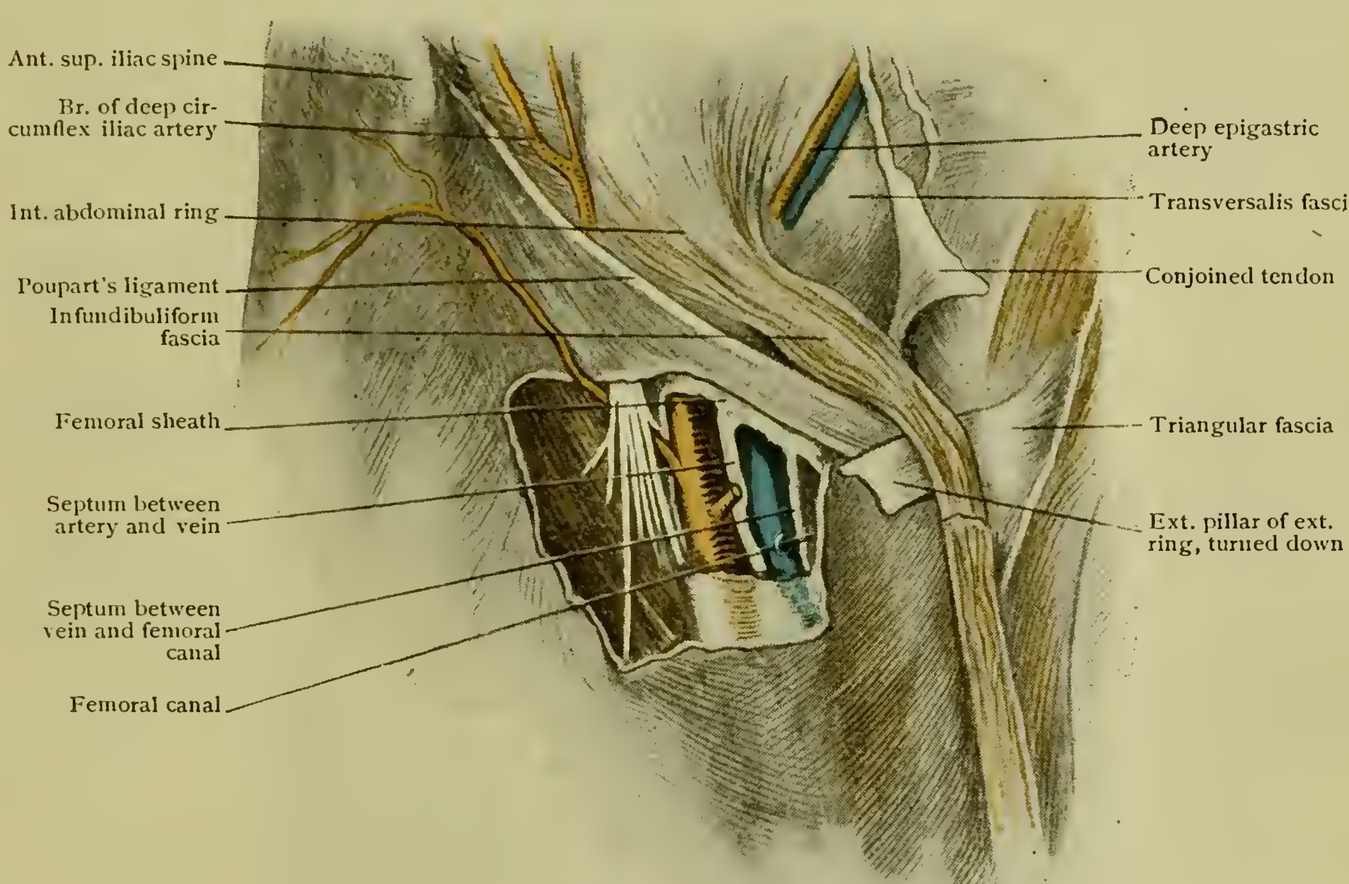

Fig. 102.—Transversalis muscle has been partially cut away to expose transversalis fascia; spermatic cord is seen issuing from internal abdominal ring, covered by infundibuliform fascia, which has been artificially distended; anterior layer of femoral sheath has been removed, showing femoral vessels and canal.

(Fig. 100). The inner margin of this portion passes downward and outward from its attachment to the spine of the pubes, forming a curved border, concave toward the inner side, which is known as the **falciform** or **Hey's ligament,** and which forms the outer boundary of the saphenous opening. This iliac portion of the fascia lies superficially to the femoral vessels. If now the falciform ligament is traced with the tip of the finger it will be found to curve round transversely and then upward and outward, becoming here the **pubic portion** of the fascia lata, which passes beneath the sheath of the femoral vessels; if it were possible to trace it completely at this stage, it would be found that the pubic portion extended outward beneath these vessels to become continuous with the

fascia covering the iliacus and psoas muscles. This may be demonstrated, in a measure, by insinuating several fingers beneath the vessels and displacing them forward and outward. The cribriform fascia should now be carefully removed from the saphenous opening in order to demonstrate this aperture, when it will be seen that the femoral vein and, to a variable but usually less extent, the femoral artery, covered by a layer of fascia, appear at this opening (Fig. 100). The layer of fascia just referred to as covering the vessels is the anterior wall of their sheath, the **femoral sheath,** which latter is derived from the transversalis fascia

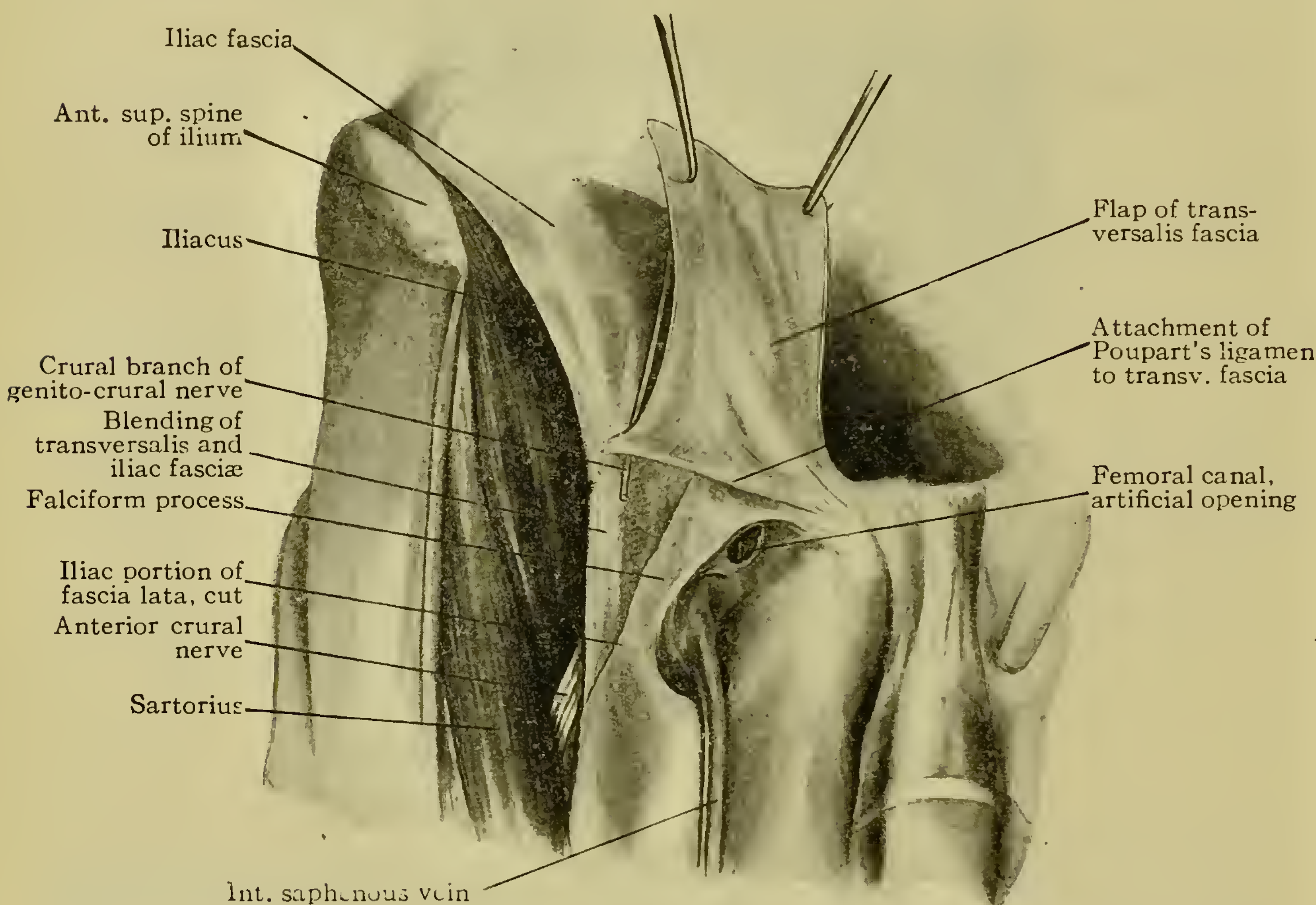

FIG. 103.—Dissection showing formation of femoral sheath, within the outer two thirds of which the femoral artery and vein are seen.

of the abdomen and the iliac fascia of the iliac fossa, these being prolonged respectively upon the anterior and posterior surfaces of the vessels and uniting laterally with each other to form a tubular sheath for them (Fig. 103). A thin layer of fascia separates the vein from the artery and a second thin layer or septum, in relation with the inner side of the vein, separates the latter from the innermost portion of the sheath, which is unoccupied, therefore, by either the artery or the vein (Fig. 102). This innermost compartment of the sheath is known as the **femoral canal,** a passage-way which has a length of about a half inch and which opens into the abdominal cavity above by an orifice known as the **femoral ring.** Its inferior orifice is said to be the saphenous opening

of the fascia lata, which is not technically correct, however, since there is no break in the sheath of the vessels at the situation of the saphenous opening. Since the sheath below the saphenous opening becomes more tightly adherent to the vessels, and since a portion of intestine forced from the abdominal cavity through the femoral ring into the femoral

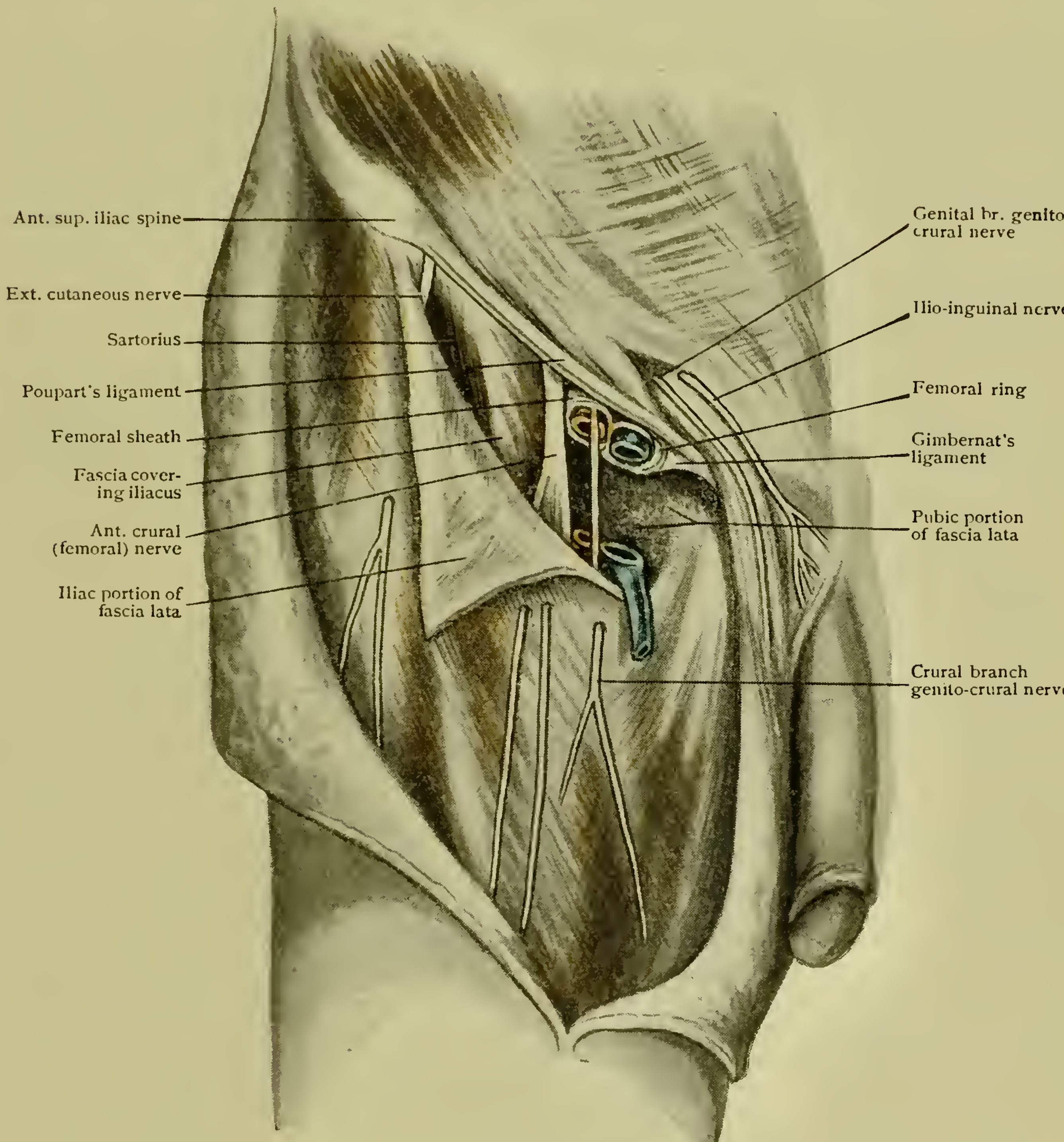

FIG. 104.—Dissection of fascia lata in Scarpa's triangle, showing the iliac portion detached from Poupart's ligament and reflected outward.

canal would travel toward the surface through the saphenous opening as the pathway of least resistance, this opening becomes, in effect, the inferior aperture of the femoral canal. This may be demonstrated by injecting fluid into the canal from the abdominal cavity through the femoral ring, or by forcing some soft substance or the little finger through the canal to the position of the saphenous opening (Fig. 101). The sheath

may be demonstrated by making an incision from the spine of the pubes outward along Poupart's ligament for about three inches and carefully raising the upper, inner portion of the iliac sheet of the fascia lata and reflecting it outward (Fig. 104).

If the finger be passed into the femoral ring from the abdominal cavity, it will be found that the ring is bounded internally by a sharp border of tense fascia; this is the outer, free concave margin of Gimbernat's ligament, which is a small triangular sheet attached by its superficial border to Poupart's ligament, by its deep border to the ilio-pectineal line and by its apex to the spine of the pubis, while the base of the triangle, directed outward, is the free concave margin already mentioned (Fig. 105). The femoral canal must be regarded as a potential rather than an actual space which is not patulous except when something is forced into or through it. The femoral ring is occupied by a little loose areolar tissue, the **septum crurale** or **fascia of Cloquet,** and occasionally by a lymph-node. A segment of intestine passing into or through this canal constitutes a **femoral hernia.** The **coverings** of such a hernia in the order of acquisition would be the parietal peritoneum, the sub-serous areolar tissue, the septum crurale and, at the moment of passing through the saphenous opening, the sheath of the vessels, the cribriform fascia, the superficial layer of the superficial fascia and the skin.

Sinee a femoral hernia, after traversing the saphenous opening, usually passes upward toward or over Poupart's ligament, it may be eonfused with an inguinal hernia; thus it is important to recognize the position of the base of the hernial tumor and its relation to the spine of the pubis, the femoral hernia being necessarily below the pubic spine, while the inguinal hernia is above it. The relation of the femoral hernia to the femoral vessels is also of importance, its position being necessarily upon the inner side of the vessels. If the thigh be abducted strongly, it will be found that the margins of the saphenous opening and the walls of the femoral sheath become tense, while if the thigh be adducted and rotated inward and slightly flexed, these structures become relaxed; hence the latter position is the proper one for performing *taxis* in the reduction of femoral hernia. The palpation of the femoral ring as indicated above will show that the most tense portion of the series of apertures through whieh the hernia passes is the inner margin of the femoral ring, or, in other words, the base of Gimbernat's ligament, which is the usual seat of constriction in strangulated femoral hernia and whieh, therefore, must be incised in order to relieve the strangulation. The obturator artery, whieh usually arises from the anterior trunk of the internal iliac and enters the thigh through the upper part of the obturator foramen, may arise from the deep epigastric (Fig. 297), in which case it may pass downward toward the obturator foramen, either along the outer side of the femoral ring in close relation with the femoral vein or along the inner side of the ring skirting the base of Gimbernat's ligament. In the latter case it is liable to injury in the operation of incising the outer edge of Gimbernat's ligament for the relief of strangulated femoral hernia.

Scarpa's Triangle.—**Boundaries:** internally, the adductor longus muscle; externally, the sartorius; above, Poupart's ligament (Fig. 105). The surface of the sartorius muscle, so far as this muscle takes part in forming the outer boundary of Scarpa's triangle, should be denuded,

the dissector not forgetting that the middle cutaneous nerve perforates the muscle. The adductor longus muscle should also be cleaned, although it will not be possible to complete its dissection until later. The crural branch of the genito-crural nerve should now be looked for on the anterior surface of the femoral artery, the femoral sheath being

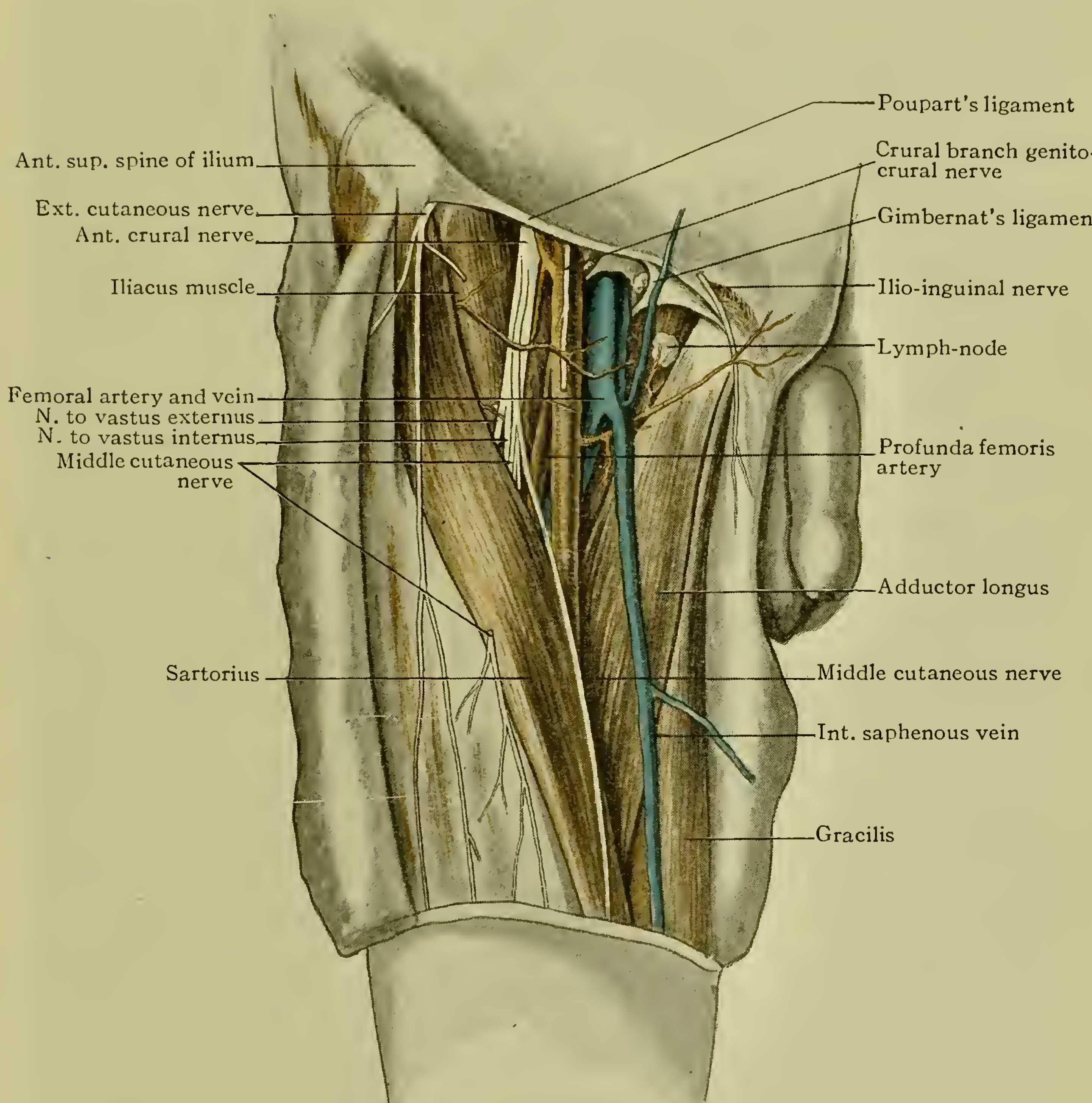

FIG. 105.—Dissection of Scarpa's triangle.

opened for this purpose. The division of the iliac portion of the fascia lata from Poupart's ligament should be completed by prolonging the incision already made outwardly to the anterior superior spine of the ilium, taking pains to avoid cutting too deeply. This flap may be reflected outward and downward with due regard for the safety of the nerves already dissected. The fascia lata may also be incised in a line extend-

ing downward from the lower margin of the saphenous opening to the sartorius muscle.

The Anterior Crural Nerve (n. femoralis).—The anterior crural nerve lies a half inch to the outer side of the femoral artery, having come from the abdomen under Poupart's ligament (Fig. 105). It is a branch of the lumbar plexus, being derived from the first, second, third and fourth lumbar nerves, and may appear in the upper part of this triangle at first as a single trunk at once dividing into an *anterior* and a *posterior set* of branches, or the division may have occurred before the nerve enters the thigh.

The **anterior division** gives off the *middle cutaneous*, the *internal cutaneous* and sometimes the *internal saphenous nerves*.

The **middle cutaneous nerve** (Fig. 105) passes downward to the deep surface of the sartorius muscle, which muscle it perforates and supplies, and then makes its appearance upon the surface of the fascia lata as noted above.

The **internal cutaneous nerve** (Fig. 107) should now be traced downward and inward, the nerve crossing the femoral vessels usually superficially but sometimes passing beneath them.

The **long** or **internal saphenous nerve** (Fig. 108) passes downward and inward and joins the femoral artery and vein at the apex of Scarpa's triangle.

The **posterior division** gives rise to all the *muscular branches* save those for the sartorius and usually also to the *internal saphenous*. The **muscular branch to the vastus internus** (Fig. 105) passes downward and inward and should be traced to the lower limit of the triangle. The **muscular branch to the crureus,** which may consist of several trunks or which may branch from the nerve to the vastus internus, is scarcely accessible at this stage of the work but may be traced to such extent as may be possible. The **muscular branch to the vastus externus** (Fig. 105) passes downward and slightly outward and can be traced but a short distance at the present stage of the work. The **muscular branch to the rectus** passes at first downward and then curves outward and upward to reach the deep surface of the upper part of the rectus, giving off before its termination an **articular branch** to the hip-joint (Fig. 108). The **muscular branch to the pectineus** passes inward beneath the upper part of the femoral vessels to reach that muscle. The further course of the branches which pass beyond the limits of the triangle will be followed in the dissection of the remaining part of the thigh.

The **external cutaneous nerve** should be sought close to the anterior superior spine of the ilium and traced downward to the point where it has been seen to perforate the fascia lata.

The Femoral Artery.—The femoral artery (see also p. 206) should now be denuded of its fascial investment, care being exercised to avoid

any branches which may be encountered, the removal of the sheath being begun at Poupart's ligament and continued downward to the apex of Scarpa's triangle. Working downward, the **branches** encountered are the **superficial epigastric,** the **superficial external pudic,** arising from the superficial aspect of the vessel (Fig. 98), the **superficial circumflex iliac,** arising from the superficial or outer aspect and perforating the fascia lata a little external to the saphenous opening, and the **deep external pudic** which arises from the inner aspect of the vessel and passes usually under the femoral vein in its course inward to the pubic region and the external genitalia (Fig. 108). All these vessels arise between the origin of the femoral and a point about an inch and a half below its origin, a part of the vessel which is known as the *common femoral* since it gives off the large deep femoral or **profunda femoris** from its outer aspect about an inch and a half below Poupart's ligament. The only other branches in Scarpa's triangle are **muscular branches.**

The Profunda Femoris.—Having completed the dissection of the common femoral artery and its branches, the dissector should follow the profunda femoris from its origin downward and inward beneath the superficial femoral artery and the femoral vein. Very near the origin of the profunda he will encounter the first of its **branches,** the **external circumflex** (Fig. 108), a large trunk which passes transversely outward between the two divisions of the anterior crural nerve and divides into *ascending branches*, passing up toward the crest of the ilium beneath the tensor fasciæ femoris, to anastomose with the gluteal and deep circumflex iliac arteries; the *transverse branches* which pass around to the outer and posterior aspect of the thigh to aid in forming the crucial anastomosis (Fig. 91); and the *descending branches* which pass downward along the outer aspect of the front of the thigh in company with the nerve to the vastus externus (Fig. 109) and which join in the anastomosis about the knee-joint. The second branch of the profunda is the **internal circumflex,** which can be traced only a short distance at this stage, the vessel passing deeply between the psoas and pectineus to reach ultimately the back of the thigh by going through the interval between the quadratus femoris and the adductor magnus where it aids in forming the crucial anastomosis. The terminal branches of the internal circumflex, the *ascending ramus* running toward the digital fossa and the *descending ramus* (Fig. 84), both contributing articular branches to the hip-joint, were encountered in the dissection of the posterior surface of the thigh. The third branch of the profunda, the **superior** or **first perforating artery,** passes deeply above the upper border of the adductor brevis to perforate the adductor magnus in its course to the back of the thigh. The remaining branches of the profunda, the **second** and **third perforating** and the terminal branch, the **fourth perforating,** will be dissected later.

The anastomosis between the ascending branches of the external circumflex, the deep circumflex iliac branch of the external iliac, and the superior gluteal from the posterior trunk of the internal iliac will come into play after ligation of the common femoral.

The **femoral vein** should now be denuded from Poupart's ligament to the apex of Scarpa's triangle, the dissector having regard for the large venous trunks corresponding to the profunda femoris and its branches which enter the femoral vein from the deep parts of the thigh.

Having identified and dissected the various vessels and nerves, the muscles forming the **floor** of this space, the iliacus, the psoas and the pectineus, should now be denuded. Beginning at the outer side of the triangle the **iliacus muscle** should be cleaned. The origin and insertion are given on page 680. To the inner side of this muscle is the **psoas muscle** (origin and insertion, page 677). The fascial investments of these muscles having been removed, they should be followed to their insertion into the lesser trochanter of the femur.

In *fracture of the upper third of the shaft of the femur*, the psoas and iliacus are apt to cause some difficulty in the matter of maintaining proper apposition of the fragments, their persistent contraction flexing, and thus tilting forward the upper fragment, a difficulty which may usually be overcome by flexing the lower fragment to such extent as will bring it into line with the upper.

A *psoas abscess* is a collection of pus within the sheath of the psoas muscle resulting usually from disease of the lumbar or thoracic vertebræ. Following the course of the psoas muscle beneath Poupart's ligament, the pus is apt to point or approach the surface at the lower part of the muscle external to the femoral artery, or it may break through the sheath of the psoas here and pass downward between the muscles of the thigh to the popliteal space. When pointing in Scarpa's triangle, a psoas abscess might simulate a femoral hernia; the importance of bearing in mind its relation to the femoral sheath is, therefore, evident.

The pectineus muscle (Fig. 107) should be cleaned and its relation to the floor of the triangle noted.

The Pectineus Muscle.—**Origin,** the ilio-pectineal line and the bone immediately in front of it; **insertion,** the rough line leading from the lesser trochanter of the femur to the linea aspera; **nerve-supply,** the anterior crural nerve—occasionally, the obturator nerve; **action,** flexion, adduction and external rotation of the thigh.

The **accessory obturator nerve** (Fig. 109), arising from the third and fourth lumbar nerves of the lumbar plexus, will be found under the outer border of the upper part of the pectineus muscle, which latter should be elevated in order to detect the nerve. This nerve supplies a **branch** to the hip-joint and a **muscular branch** to the pectineus and communicates with the obturator nerve. It is not always present.

The Relations of the Femoral Vessels.—The dissection of the contents and of the floor of Scarpa's triangle having been completed, the relations of the femoral vessels should now be considered. The **femoral**

artery having its **origin** beneath the middle of Poupart's ligament, as the continuation of the external iliac artery, passes through the middle of the triangle to its apex, and, after traversing Hunter's canal (see below) and perforating the adductor magnus, enters the popliteal space to **terminate** as the popliteal artery. The **surface line** indicating its course is from a point mid-way between the anterior superior spine of the ilium and the spine of the pubis to the adductor tubercle of the inner condyle of the femur.

From its point of origin to the giving off of its largest branch, the profunda femoris, it is known as the **common femoral artery,** while in the remaining part of its course it is known as the **superficial femoral.** Its **branches** as well as those of the profunda (so far as they concern Scarpa's triangle) are given above.

It is related on its *outer side* with the anterior crural nerve and its branches, the nerve being distant about a half inch, while lying in close relation with its outer side near the apex of the triangle are the internal saphenous nerve and the muscular branch to the vastus internus. On the *inner side* it is related to the femoral vein in the upper part of the space, the vein gradually getting beneath the artery as the two vessels approach the apex of the triangle. *In front* of the artery, just within its sheath, is the crural branch of the genito-crural nerve, while crossing the vessel lower down is the internal cutaneous nerve; more superficially it is covered by its sheath, the iliac portion of the fascia lata, the cribriform fascia, the superficial fascia and the skin. *Behind*, the artery rests from above downward upon the psoas, the iliacus, the pectineus and the adductor brevis, the muscular branch to the pectineus passing behind its upper portion. The relation of the artery to the hip-joint and the femur is an important one. Since at the beginning of its course it passes across the front of the joint, from which it is separated by the ilio-psoas and the bursa beneath it (Fig. 112) and gradually reaches the inner aspect of the femur, pressure to control hemorrhage would be made directly backward over the upper part of the artery, this direction gradually changing to backward and outward as the apex of Scarpa's triangle is approached.

The femoral artery is sometimes the seat of *aneurism* and from its superficial position is liable to *injury*. For either condition ligation may be required, which may be done either above or below the giving off of the profunda.

The Femoral Vein.—The femoral vein, **beginning** in the popliteal space as the continuation of the popliteal vein and **terminating** at Poupart's ligament as the external iliac vein, receives as its **tributaries** the veins corresponding to the branches of the femoral artery and in addition the *internal saphenous vein*. Many of the smaller tributaries, such as those corresponding to branches of the common femoral artery, do not drain directly into the femoral but into the internal saphenous. The **profunda femoris vein** is noteworthy on account of its size. The

femoral vein contains a variable number of valves—from one to five—the most constant of which is located in the upper extremity of the vein. The **relations** and **course** of the femoral vein have been sufficiently dwelt upon in treating of the femoral artery and the femoral sheath.

The position of the femoral vein is directly related to its liability to *injury;* the seriousness of such injury by reason of the size of the vein is worthy of note.

Inflammation, phlebitis, of the femoral vein is not an infrequent sequel or complication of certain diseases and operations or of general septic states of the system. It seems to occur with especial frequency on the left side of the body after abdominal sections, the reason for which does not seem clear.

The *internal* or *long saphenous vein,* part of which has been seen in Scarpa's triangle, the longest superficial vein of the lower extremity, is subject to *varicosity* by reason of its length and the direction of its blood current.

THE SURFACE ANATOMY OF THE LOWER PART OF THE THIGH AND KNEE.

The **patella,** plainly obvious to sight and touch on the front of the knee, may be moved from side to side when the leg is passively extended upon the thigh, and one may trace from its lower border the large tendon of the quadriceps or the **tendo patellæ** to its insertion into the **tubercle of the tibia,** which also is easily palpable, while from its upper border may be traced the shorter but broader **tendon of insertion of the rectus femoris.** On either side of the knee the corresponding **condyle** of the femur is plainly palpable, the **inner one** presenting at its upper part a prominence, the **adductor tubercle,** which marks the limit of insertion of the adductor magnus muscle, the tendon of this muscle being recognizable at its insertion into the tubercle when the thigh is abducted. Just below the inner condyle is the **inner tuberosity** or inner part of the head **of the tibia,** passing across which are the tendons of the sartorius and gracilis on their way to their insertion into the upper part of the shaft of the tibia. These two tendons with the tendons of the semitendinosus and semimembranosus are designated the inner hamstring tendons and constitute the inner boundary of the upper part of the popliteal space. Below the outer condyle on the outer aspect of the knee the **head of the fibula** may be felt as well as the interval which separates it from the outer condyle. The **tendon of the biceps** (Fig. 80) is palpable above and somewhat behind the outer condyle as a tense cord when the knee is flexed, this cord being traceable to the head of the fibula. The **peroneal** or **fibular nerve** (external popliteal) is obscurely felt upon the inner side of the biceps tendon on the posterior aspect of the thigh, and in the living subject may be easily followed around to the anterior aspect of the leg as it crosses the outer side of the head of the fibula. The **outer tuberosity of the tibia** is most plainly evident on the antero-external aspect of the knee.

THE DISSECTION OF THE ANTERIOR AND INNER ASPECTS OF THE THIGH.

Making a median, longitudinal incision through the skin down the front of the thigh across the patella and its tendon to a point an inch below the tubercle of the tibia, and a transverse incision at the lower extremity of this extending half way around the leg, the skin-flaps thus outlined (Fig. 97) should be reflected to the extent necessary to expose the inner and outer surfaces of the thigh and knee. In the region of the knee the dissection of the skin should be done with particular caution to avoid injuring the terminations of the various **cutaneous nerves** (Figs. 106 and 120) which ramify here, and also to enable the dissector to detect the **prepatellar bursa** which lies between the patella and the skin. This bursa may be demonstrated by distention of its sac with water. In dissecting the skin from the inner aspect of the knee, in addition to looking for the cutaneous nerves, the **internal saphenous vein,** which lies posterior to the inner condyle, and the **superficial branch of the anastomotica magna artery** should be preserved (Fig. 108). In denuding the outer side of the knee, while caring for the cutaneous nerves as before, the small arteries of the part, constituting a portion of the circumpatellar anastomosis, should be regarded.

The **circumpatellar anastomosis** (rete patellæ) is a network of vessels (Figs. 108 and 123) formed by the inosculations of the internal and external articular branches and the muscular branches of the popliteal, the anterior recurrent tibial, the anastomotica magna and the descending branches of the external circumflex. Whatever portions of these vessels are to be found in the superficial fascia should be worked out at this stage, the deeper ramifications of the vessels being left until later.

The Superficial Fascia.—The superficial fascia presents no special features, having the usual adipose constituent, except in the immediate vicinity of the knee, where the adipose element may be deficient unless the subject is very fat. The **cutaneous nerves** which have been exposed in the region of Scarpa's triangle should now be dissected in succession to their terminations.

The **external cutaneous nerve** (*anterior branch*) should be picked up in the upper part of the thigh and followed downward to its termination at the outer side of the knee (Fig. 106). The *posterior branch* which parts company with the anterior at a point anywhere from one half to three or four inches below Poupart's ligament, may be traced toward the lateral and posterior surfaces of the thigh.

The **middle cutaneous nerve** (page 198), consisting usually of two trunks one or both of which may perforate the sartorius, which they supply with motor twigs, should be traced downward to their termina-

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tion in the superficial patellar nerve-plexus (Fig. 106). Commonly the inner branch crosses the sartorius near the apex of Scarpa's triangle without traversing its substance.

The **internal cutaneous nerve** (page 198) should be picked up in Scarpa's triangle and traced downward (Fig. 107). It divides into an *anterior branch*, which should be followed downward along the inner part of the anterior surface of the thigh, perforating the fascia lata in the lower third (Fig. 106), and a *posterior branch*, which must be traced along the inner aspect of the thigh beneath the sartorius, where it will be found usually to communicate with the internal saphenous and the obturator nerves; it emerges through the fascia lata at the inner side of the knee (Fig. 106) to terminate in cutaneous filaments distributed to this region.

The **internal saphenous nerve** (page 204) should be traced through Scarpa's triangle to the point where it enters the aponeurotic canal with the femoral artery and vein. It pierces the roof of this canal at about the junction of the lower third with the middle third of the thigh over the course of the femoral vessels (Fig. 107), and becomes a constituent of the superficial fascia from this point downward. It will be found at the inner side of the knee in close relation with the internal saphenous vein and the superficial branch of the anastomotica magna artery, and continues its course to the inner side of the leg and foot (p. 252). The **branches** of the internal saphenous in the thigh are the *communicating*, arising beneath the sartorius in the middle third of the thigh and joining with branches of the obturator and internal cutaneous nerves to form the *obturator* or *subsartorial plexus*, and the *infrapatellar branch*. This plexus will be worked out upon the reflection of the sartorius. A few inches above the inner condyle, or sometimes lower, the nerve gives off its *cutaneous patellar branch* (infrapatellar), which curves inward and forward below the patella, distributing cutaneous branches as it goes to terminate on the outer side of the upper part of the leg (Fig. 106) and to aid in forming the patellar plexus. This nerve, as well as the cutaneous nerves generally in the vicinity of the front of the knee, appears as a rather broad, pearly or bluish-white band in the superficial fascia.

The **cutaneous branch of the obturator nerve** will usually be found passing down along the inner side of the thigh in the superficial fascia, emerging through the deep fascia at about the middle of the thigh, and sometimes may be found by following backward some of the branches by which it communicates with the subsartorial plexus and with the posterior branch of the internal cutaneous and the internal saphenous nerves (Fig. 107). In many cases this nerve is small or absent, being replaced wholly or in part by the internal cutaneous nerve.

If these various nerve-trunks have been successfully traced, it will be seen that the cutaneous supply of the front of the knee is contributed

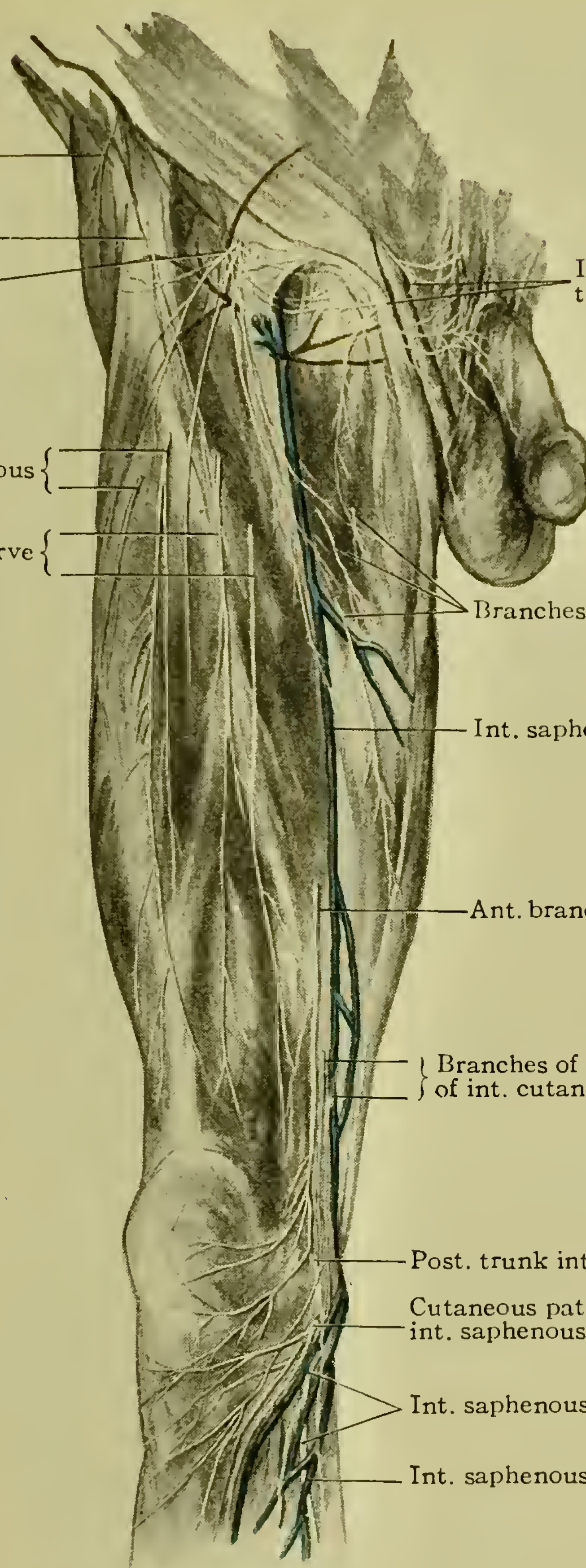

Fig 106.—Superficial nerves and veins of front of thigh.

to by the external cutaneous, the middle cutaneous, the internal cutaneous and the patellar branch of the internal saphenous nerves, aided possibly by the obturator.

The **internal saphenous** vein should be cleaned to the lower limit of the dissection and so much of the superficial branch of the anastomotica magna artery as can be dissected at this stage should be cleared

of connective tissue. The terminal portion of the **anterior recurrent tibial artery,** ramifying upon the outer side of the front of the knee, should also be dissected with whatever other superficial arteries it anastomoses, such as the **articular branches** of the popliteal (Fig. 123). The remnants of the superficial fascia should now be removed in order to expose the fascia lata.

THE FASCIA LATA.—The upper portion of the fascia lata, including its iliac and pubic subdivisions, having been dissected, the dissector should note the attachment of this deep fascia of the thigh to the bony prominences about the knee, such as the condyles of the femur and the tubercle and the tuberosities of the tibia. He should note also an opaque band of the fascia which is seen upon the outer aspect of the thigh stretching from near the anterior part of the crest of the ilium to the head of the fibula and the outer tuberosity of the tibia, the **ilio-tibial band** (Fig. 82).

The ilio-tibial band is quite tense under normal conditions, but anything which approximates its two points of attachment, as shortening of the femur from fracture of its shaft or neck, causes relaxation of this band, which relaxation thus becomes a significant sign in such conditions, as pointed out by Allis.

The **intermuscular septa** of the fascia lata, splitting from its deep surface, are attached respectively to the inner and outer lips of the linea aspera, serving to separate the anterior thigh muscles, the extensors, from the posterior and adductor groups and giving partial origin to the muscles with which they are in relation. The **internal intermuscular septum** is interposed between the vastus internus and the adductor group; the **external intermuscular septum,** the stronger of the two, is between the vastus externus and the biceps. These septa will be better appreciated as they are encountered in the dissection of the muscles.

TENSOR FASCIÆ FEMORIS (tensor vaginæ femoris, tensor fasciæ latæ).—**Origin,** the anterior superior spine of the ilium and the adjacent part of its crest; **insertion,** the fascia lata at the junction of the upper and middle thirds of the thigh; **nerve-supply,** the superior gluteal nerve (fourth and fifth lumbar and first sacral); **action,** to pull upon the fascia lata; flexion and inward rotation of the thigh.

This muscle (Fig. 107), enclosed between the two layers of the fascia lata, will be exposed by incising the latter fascia in a line passing downward from the anterior superior spine of the ilium. The fascia should also be removed from its deep surface. The ilio-tibial band referred to in the last paragraph acts almost as a tendon of the muscle, so that the latter may expend some of its force upon the tibia. In raising the muscle the ascending branches of the external circumflex artery will be encountered in relation with its deep surface and passing upward and backward behind its posterior border.

THE SARTORIUS.—**Origin,** the anterior superior spine of the ilium and part of the notch below it (Fig. 105); **insertion,** the upper part of

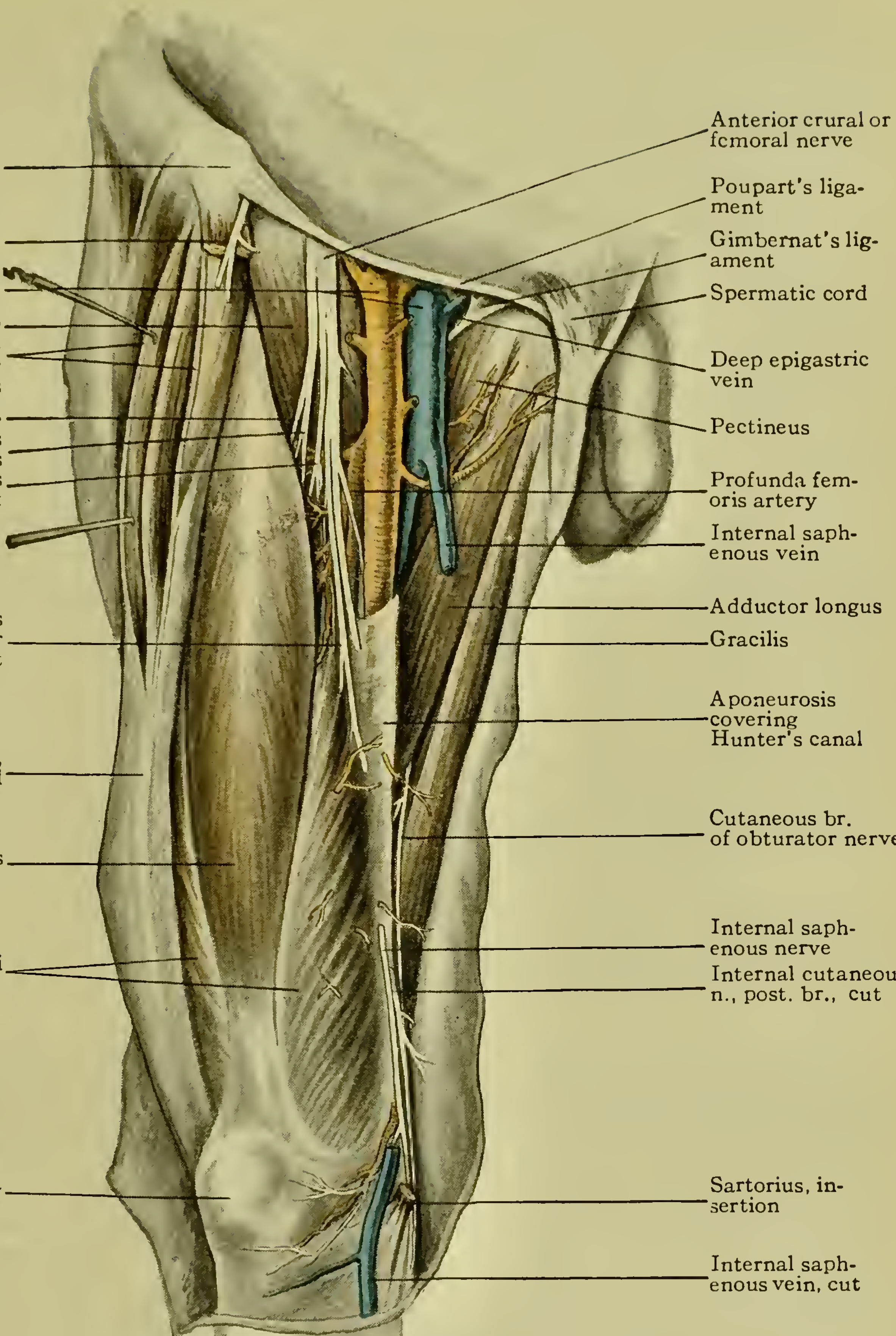

Fig. 107.—Dissection of front of thigh showing Hunter's canal.

the shaft of the tibia in company with the tendons of the gracilis and semitendinosus, the aponeurosis of the sartorius embracing the other tendons at its point of attachment to the tibia; **nerve-supply,** the middle cutaneous branch of the anterior crural (second and third lumbar); **action,** flexion of the leg and thigh and external rotation of the thigh.

This muscle having been already partially cleaned, its denudation should be continued to its point of insertion, the dissector being on guard for the cutaneous nerve-trunks that are in relation with its lower half, that is, the posterior branch of the internal cutaneous and the cutaneous branch of the obturator. Beneath the muscle, somewhat internal to the apex of Scarpa's triangle, the **subsartorial plexus** will be found, composed of branches from the obturator, the internal saphenous and the internal cutaneous. The relation of the sartorius to Scarpa's triangle and its perforation by the middle cutaneous nerve have been noted. The lower half of the muscle may be carefully elevated, with due regard for the nerves mentioned above, in order to expose the region of Hunter's canal.

THE QUADRICEPS EXTENSOR.—**Origin:** the **rectus** from the anterior inferior spine of the ilium (straight tendon) and the groove above the acetabulum (reflected tendon) (Fig. 112); the **vastus externus,** the upper half of the anterior intertrochanteric line, the tubercle of the femur, the outer lip of the gluteal ridge and the upper half of the outer lip of the linea aspera; the **vastus internus,** the lower half of the anterior intertrochanteric line, the spiral line of the femur, the entire length of the inner lip of the linea aspera and the upper part of the inner supracondylar line; the **crureus,** the upper and outer aspects of the upper two thirds of the shaft of the femur. **Insertion,** by aponeuroses and a tendon (for the rectus) which converge to the patella, being attached to it and enclosing it, and which still further converge to a large, thick tendon, the **tendo patellæ,** extending from the lower border of the patella to the tubercle of the tibia (Fig. 107); **nerve-supply,** the anterior crural nerve (third and fourth lumbar); **action,** extension of the leg, the rectus also aiding in flexion of the thigh and in flexion of the pelvis upon the thigh.

The Rectus Femoris.—This part of the quadriceps should first be denuded from its origin to its insertion, the straight tendon of origin being traced to its attachment to the anterior inferior spine of the ilium. The superficial surface having been denuded, the muscle may be elevated and then inverted and its deep surface at least partially cleaned, when the muscular branch of supply will be found entering this surface in the upper third of the thigh. It will be seen that the superficial fibres are bipenniformly arranged and converge to be inserted below with the deep straight fibres into an aponeurosis on the deep surface which narrows to a tendon attaching to the upper border of the patella.

The Vastus Externus.—The outer surface of this portion of the quadriceps should first be cleaned and the aponeurosis on the upper two thirds of this surface should be noted and traced to the posterior aspect of the thigh. The anterior border of the vastus in relation with the outer border of the rectus should now be elevated, when the descending branches of the external circumflex artery in company with the nerve to the vastus

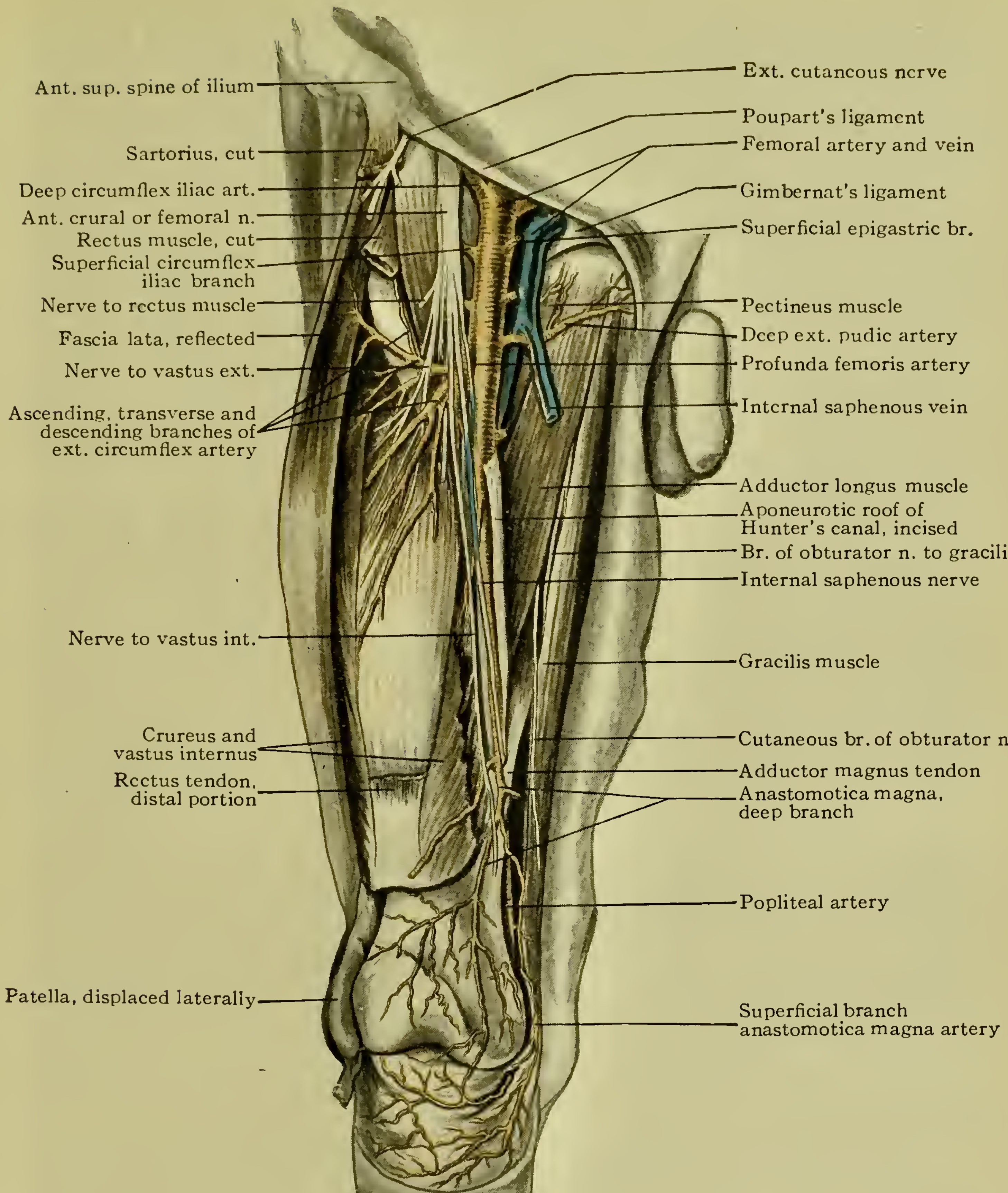

FIG. 108.—Deep dissection of front of thigh; femoral artery and vein; anterior crural nerve. The rectus femoris and the sartorius have been removed.

externus will be found in relation with this deep surface (Fig. 108). Pulling the vastus externus outward will give better access to these structures and will also show that this surface of the vastus externus is largely aponeurotic. With the fingers it may be traced to its attachment to the linea aspera on the posterior aspect of the femur. The attachment

of the aponeurosis of insertion to the lateral border of the patella should be noted. The nerve and artery or arteries mentioned above should be followed not only into the muscle, but through its substance toward the knee. In a successful injection the arteries may be traced to the region of the knee and be found to anastomose with the external articular branches of the popliteal.

The Vastus Internus and Crureus.—These two parts of the quadriceps are so intimately connected that they may be considered together (Fig. 108). The inner border of the rectus indicates fairly accurately the dividing line between the crureus and the inner vastus. Following the former it will be seen that it covers the anterior and the outer surfaces of the femoral shaft for its upper two thirds and, therefore, is for the most part covered by the vastus externus, as will have been already seen. Traced downward, the aponeurosis of the crureus is seen to narrow and blend with the deep part of the tendon of the rectus. The nerve to the crureus will be found entering it either upon the outer aspect of the thigh above, having come from the branch to the vastus externus, or more anteriorly, having arisen in this case from the branch to the vastus internus (Fig. 108). The surface of the vastus internus should be denuded, followed upward to the anterior intertrochanteric line and then inward to the position of Hunter's canal, that is, to the line marking the course of the femoral artery. Here the inner surface of this muscle will be seen to give attachment to an aponeurosis or layer of fascia which passes inward to be attached to the surfaces of the adductor longus and magnus muscles. This aponeurosis constitutes the roof of Hunter's canal and should be left undisturbed for the present, which interferes with the complete dissection of the vastus internus at this stage.

The Gracilis.—**Origin,** the lower half of the inner border of the body of the pubis, and the upper part of the descending pubic ramus; **insertion,** the upper part of the inner surface of the shaft of the tibia, its tendon being embraced by the insertion of the sartorius; **nerve-supply,** the anterior division of the obturator nerve (second, third and fourth lumbar); **action,** flexion and adduction of the thigh and flexion of the leg (Fig. 107).

The dissector should clean first the superficial surface of this muscle and then should inspect its deep surface, having carefully loosened the muscle, when he will find the nerve of supply entering the deep surface in the upper third. This nerve if traced upward will lead the dissector beneath the adductor longus to its parent trunk, the obturator nerve.

The Adductor Longus.—**Origin,** by a narrow tendon from the front of the pubic bone immediately in front of its spine; **insertion,** the linea aspera about its middle third; **nerve-supply,** the anterior division of the obturator nerve (second and third lumbar); **action,** adduction and, secondarily, flexion and eversion of the thigh.

This muscle was partly dissected in demonstrating Scarpa's triangle and should now be cleaned down to the point of attachment of the aponeurotic roof of Hunter's canal. Elevating the muscle, its nerve of supply will be seen entering the upper part of its deep surface.

The **pectineus muscle,** the origin and insertion of which were studied in the dissection of Scarpa's triangle, is in the same plane with the adductor longus. Its anterior surface if not already clean should be denuded, when the borders of the muscle should be loosened and it should be gently raised with the fingers or blunt instruments. In doing this it will be found loosely adherent to the hip-joint capsule and several vessels and nerves will be exposed. The accessory obturator nerve, under the upper part of its outer border, has already been mentioned. Raising the inner border of the muscle and pulling it inward, one may reach the **obturator nerve** just as it emerges from the pelvis through the obturator foramen, and along the lower part of its inner border the **internal circumflex artery** will be encountered; this should be followed beneath the pectineus. Its branches respectively to the digital fossa of the femur and to the surface of the obturator externus muscle should be noted and the continuation of the artery to the interval between the upper border of the adductor magnus and the quadratus femoris traced (p. 205).

The Adductor Brevis.—**Origin,** the front of the body and of the descending ramus of the pubis; **insertion,** the upper third of the linea aspera; **nerve-supply,** the anterior division of the obturator nerve (the third and fourth lumbar); **action,** adduction, flexion and eversion of the thigh (Fig. 109).

This muscle, lying beneath the adductor longus, may be exposed by displacing that muscle, or, if desired, by detaching it from its origin and reflecting it downward. In denuding its superficial surface the **anterior division of the obturator nerve** and some of its branches will be encountered (Fig. 109). These nerve-trunks should be cleaned and pulled aside in order to thoroughly expose the muscle, after which the latter may be elevated, when the **posterior division of the obturator nerve** will be encountered on its deep surface between it and the adductor magnus. These nerves should also be followed upward toward their origin and downward toward their termination in the various muscles which they supply.

The Adductor Magnus.—**Origin,** the tuberosity of the ischium, the ramus of the ischium and the inferior ramus of the pubis; **insertion,** the whole length of the linea aspera and its outer prolongation above and its inner prolongation below, the lowest part of the muscle terminating in a rounded tendon which is attached to the adductor tubercle of the inner condyle of the femur; **nerve-supply,** the posterior ramus of the obturator (third and fourth lumbar); **action,** adduction and eversion of the thigh. The upper part of the muscle is sometimes designated the *adductor minimus* (Figs. 108 and 93).

In cleaning the anterior surface of this muscle, having displaced first the adductor longus and brevis, the dissector will encounter above some of the branches of the obturator nerve, which should be followed upward to their origin and downward to their termination.

Hunter's canal, previously referred to as an aponeurotic passage-way traversed by the femoral artery and vein and the internal saphenous nerve, is in relation with the anterior surfaces of the adductor magnus and adductor longus in the middle third of the thigh and with the inner surface of the vastus internus. The aponeurosis which forms the roof of the canal connecting the vastus internus with the two adductors (Fig. 107) should now be examined, and the emergence of the internal saphenous nerve and the superficial branch of the anastomotica magna artery through this aponeurotic roof near its lower end should be noted (Fig. 107), as should also any discoverable *muscular branches* of the femoral artery. This canal should now be opened and the femoral artery and vein and the saphenous nerve exposed. The completion of the dissection of the anterior surface of the adductor magnus may now be effected, when it will be seen to be attached to the linea aspera and to present **five apertures** for arteries. The **first** of these is above the position of the adductor brevis and transmits the first perforating branch of the profunda femoris; the **second** is beneath the adductor brevis, transmitting the second perforating branch; the **third** is below the adductor brevis for the third perforating branch; the **fourth** is still lower for the transmission of the fourth perforating branch or termination of the profunda itself, while the **fifth aperture,** the largest, is near the lower extremity of Hunter's canal and transmits the femoral artery to the popliteal space and the popliteal vein from that space (Fig. 93).

The Obturator Nerve.—This nerve, a branch of the lumbar plexus, getting its fibres from the second, third and fourth lumbar nerves, passes along the lateral wall of the pelvis above the obturator artery and close to it and enters the thigh through the upper part of the obturator foramen, during its passage through which it divides into its *anterior* and *posterior divisions*, the anterior passing above the obturator externus muscle, while the posterior division passes through the upper part of this muscle so that the two divisions are thus separated by some of the fibres of the obturator externus.

The **anterior branch** (Fig. 109), which should be first followed, will be seen to give an *articular branch* to the hip-joint, which curves outward and upward to the cotyloid notch, then to pass in front of the adductor brevis, distributing *muscular branches* to this muscle and to the adductor longus and gracilis. These have already been isolated. Continuing, the anterior division of the obturator sends communicating branches to unite with the internal cutaneous nerve and the internal saphenous to form the **subsartorial** or **obturator plexus,** situated beneath the sartorius

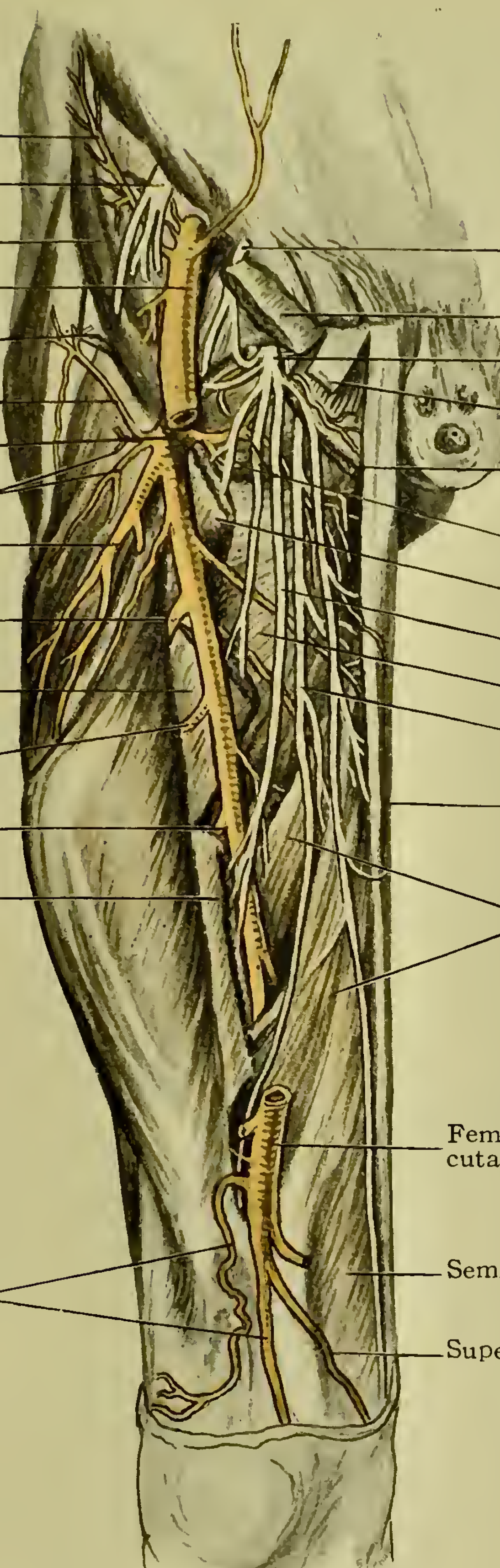

FIG. 109.—Dissection showing obturator nerve and artery and deep femoral artery.

a little above the middle of the thigh, and usually sends a *cutaneous branch*—sometimes arising from the branch to the adductor longus—to supply the skin of the inner side of the thigh and the inner side of the upper half of the leg (Fig. 109). The continuation of the anterior division, the *vascular branch*, follows the femoral artery, upon which it finally breaks up in the lower part of Hunter's canal.

The **posterior division** of the nerve (Fig. 109), emerging through the obturator externus, should be followed behind the adductor brevis, and its *muscular branches* to the anterior surface of the obturator externus and to the adductor brevis and magnus should be noted. An *articular* or *geniculate branch* to the knee-joint passes from the posterior division through the adductor magnus, often being associated with the nerve to this muscle, to reach the popliteal space, and then accompanies the popliteal artery to the posterior ligament of the knee-joint, which it perforates.

The Obturator Externus.—**Origin,** the inner and lower margins of the obturator foramen (pubic and ischiatic rami) and the lower half of the outer surface of the obturator membrane; **insertion,** the digital fossa of the femur, **nerve-supply,** the posterior division of the obturator nerve (third and fourth lumbar); **action,** external rotation of the femur (Fig. 111).

To expose this muscle the thigh must be well abducted and the pectineus, adductor longus and adductor brevis displaced or removed, preferably the former. The tendon of the muscle should be traced as far as possible after it passes outward behind the neck of the femur, although the terminal part of the tendon can only be seen to advantage in the dissection of the gluteal region (Fig. 93).

The Obturator Artery.—This artery is a branch of the anterior trunk of the internal iliac (or sometimes of the posterior trunk). Passing along the upper border of the lateral wall of the pelvis, where it gives off its *intrapelvic branches* (see dissection of pelvic structures), it leaves the latter cavity through the upper part of the obturator foramen to enter the thigh, where it divides into an *internal* and an *external branch.*

The **internal branch** passes to the inner side of the obturator foramen beneath the obturator externus muscle, which it supplies in addition to sending branches to adjacent muscles and anastomosing with the external branch.

The **external branch** skirts the outer and lower borders of the obturator foramen beneath the obturator externus, giving rise to an *internal* (intrapelvic) *branch*, which passes downward beneath the inner surface of the obturator membrane and the obturator internus muscle, and an *articular* or *acetabular branch* to the hip-joint, which enters at the cotyloid notch (Fig. 112) and supplies the fatty tissue of the acetabulum. The external branch of the obturator anastomoses with the internal circumflex.

The occasional irregular origin of the obturator artery and its relation in such cases to the femoral ring are referred to on p. 202.

The **anastomotica magna artery** (a. genu suprema), a branch of the femoral given off in the lower part of Hunter's canal, divides into a

superficial and a *deep branch*. The *superficial branch*, as previously noted, pierces the roof of Hunter's canal (Fig. 109), passes superficially back of the inner condyle and is distributed to the upper half or two thirds of the inner side of the leg, running in company with the internal saphenous vein and internal saphenous nerve. The *deep branch* burrows through the substance of the vastus internus toward the knee-joint (Fig. 108). This muscle must be incised, beginning where the artery is seen to enter it, that the artery may be followed toward the inner side of the lower end of the femur—with care for the safety of the accompanying nerve—and then, in connection with the dissection of the front of the knee (p. 222), across the front of the femur above its articular surface to anastomose on the outer side of the joint with the external articular branches of the popliteal and the anterior recurrent tibial. It also joins in the circumpatellar anastomosis.

The **muscular branch of the anterior crural nerve** to the vastus internus, entering this muscle about the upper third of the thigh, should be followed in its course through the muscle by incising the muscular fibres to the necessary extent. Near the lower end of the thigh it gives off an *articular branch* to the knee-joint.

THE REGION OF THE KNEE.

The posterior aspect of the knee has been considered in connection with the dissection of the popliteal space. The anterior aspect of the knee presents certain important bony prominences which have already been indicated (page 208). The superficial fascia of this region shows the cutaneous filaments of the internal, middle and external cutaneous nerves and of the cutaneous patellar branch of the internal saphenous nerve forming the **patellar plexus,** seen chiefly upon the inner side of the patella, but also above and upon its outer side. A superficial network of arteries, the **circumpatellar anastomosis,** made up of branches from the upper and lower articular branches of the popliteal, of branches from the anterior recurrent tibial, the anastomotica magna and the external circumflex, is also found in the superficial fascia of this region. These structures have already been traced in so far as they pertain to the superficial fascia.

The aponeurotic expansion of the vastus internus attached to the inner border of the patella and to the inner condyle of the femur should now be carefully removed, thus exposing the capsule of the joint. The aponeurotic expansion of the vastus externus attached to the outer border of the patella and the outer condyle should be similarly treated.

Beginning now at the lower inner part of the anterior aspect of the joint directly opposite the inner tuberosity of the tibia the **inferior internal articular artery** (Fig. 143) may be dissected. The vessel may

be traced inward to the anterior border of the internal lateral ligament under which it passes and at the posterior border of this ligament may be again picked up and traced round to its origin in the popliteal artery (Fig. 135). Traced upward from the point of starting it will be seen to distribute *branches* to the capsule and the patella and to anastomose with a descending branch of the superior internal articular; it also sends a branch outward under the patellar tendon to anastomose with the anterior tibial recurrent. The region over which this artery has been followed is for the most part the anterior aspect of the capsule of the joint.

The **superior internal articular artery,** appearing above the inner condyle (Fig. 135), may now be traced to the inner side of the shaft of the femur and around to its origin from the popliteal artery. A branch will be seen to pass across the shaft of the femur to anastomose with the superior external articular artery. One usually encounters here also the continuation of the deep branch of the anastomotica magna passing across the front of the femur (Fig. 108).

The **superior external articular artery** (Fig. 144) should be traced around the outer side of the shaft of the femur to its origin from the popliteal. It will be seen to send *branches* downward along the outer side of the joint to anastomose with branches of the anterior recurrent tibial. A branch from the descending division of the external circumflex artery (Fig. 144) will be found coming down along the outer side of the femur to anastomose with the superior external articular. This artery is usually accompanied by the **articular branch** from the muscular nerve of the vastus externus.

The **anterior tibial recurrent artery,** arising from the anterior tibial just as that vessel emerges through the interosseous space to reach the front of the leg (Fig. 144), will be found at the upper limit of the interosseous space emerging through the fibres of the anterior tibial muscle or in the interval between it and the extensor longus digitorum. The muscular substance should be removed to the extent necessary to fully expose the vessel. Traced upward, this artery passes along the outer aspect of the joint toward the margin of the patella, anastomosing with the inferior internal articular under the patellar tendon, with the inferior external articular and with the superior external articular, distributing branches also to the capsule as it goes.

The **inferior external articular artery** will be found almost directly opposite the interval between the outer tuberosity of the tibia and the femur. It should be traced outward to the border of the long external lateral ligament (Fig. 144) under which it passes and may be further traced around to its origin from the popliteal artery.

Owing to the free superficial nerve- and blood-supply of the front of the knee, counter-irritants designed to affect the joint are applied on either side of the patella and its tendon.

THE SUBCRUREUS MUSCLE.—**Origin,** the lower fourth of the front of the femoral shaft (Fig. 110); **insertion,** the large bursa which lies on the front of the femur above the knee-joint; **nerve-supply,** the anterior crural nerve (third and fourth lumbar); **action,** to pull the bursal sac upward during extension of the leg.

The muscle and the bursa are to be exposed by making a longitudinal incision through the vastus internus or crureus along the inner margin of the lower part of the rectus and along the inner side of the patella

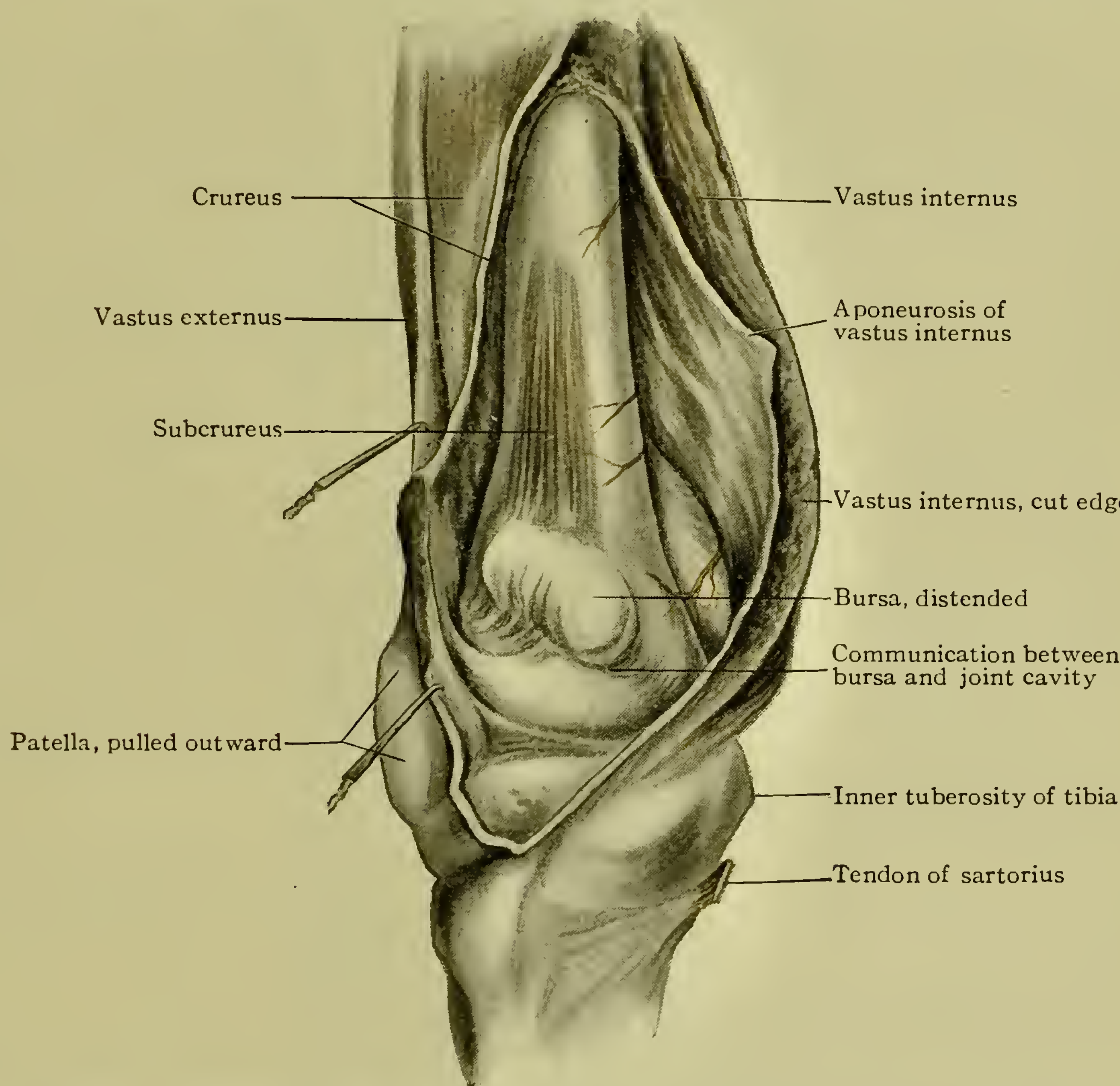

FIG. 110.—Suprapatellar bursa on front of lower part of femur with subcrureus muscle.

down to the tendo patellæ, or the incision may be terminated on a level with the upper border of the patella and the tendon of the rectus divided by a transverse cut close to the patella. The margins of this incision being retracted and the flaps thus formed loosened, the muscle in question as well as the bursa is exposed (Fig. 110).

The **suprapatellar bursa,** referred to in the last paragraph, may be demonstrated by injection with, preferably, a hardening fluid, such as

the Pausch's starch mass, in which case its continuity with the knee-joint cavity will be demonstrated if such continuity exist.

Since this bursa is in from 75 to 77 per cent. of cases in direct continuity with the knee-joint, for all practical purposes the knee-joint cavity may be regarded as extending upward upon the front of the femur for a distance of four inches above the articular line; hence a stab wound of this part of the thigh might become in effect a perforating wound of the knee-joint.

The patella, if reflected in the exposure of the subcrureus, should now be replaced in position, and the knee-joint is to be protected by being wrapped in damp cloths for dissection at a later stage of the work.

Inasmuch as it may be found desirable to disarticulate the lower limb from the trunk at this stage of the work, it is better to defer the dissection of the leg and foot and to proceed with that of the hip-joint. To expose the joint, divide the adductors, the pectineus and the tensor fasciæ femoris near their points of origin and reflect them, leaving the ilio-psoas for the moment that its intimate relation to the capsule of the joint may be appreciated, and that it may be traced to its insertion (Fig. 111) now that the structures on the inner side of the thigh have been dissected.

The Hip-Joint.—The **articular surfaces** involved in this joint are the acetabulum of the innominate bone and the head of the femur. The **ligaments** are the *capsular ligament*, which presents certain specially named thickenings (see below), the *cotyloid ligament* (labrum glenoidale), applied to the rim of the acetabulum, deficient in front and below, the notch thus formed being bridged over by the *transverse ligament*, thus leaving an aperture for the entrance of vessels; and the *ligamentum teres* or *round ligament* connecting the bottom of the acetabulum with the head of the femur. The **nerve-supply** is from the anterior division of the obturator nerve, the anterior crural (femoral) nerve through an articular filament from the muscular branch to the rectus, branches from the sacral plexus and the great sciatic nerve. The **blood-supply** is from the obturator and the sciatic arteries. The type of joint is the **enarthrodial.**

The posterior aspect of the hip-joint has been considered (page 189). The anterior aspect of the joint is in relation with the iliacus, psoas and pectineus muscles. The pectineus having been displaced, the iliacus may be elevated along its outer border to bring into view the **bursa** which separates the iliacus from the anterior surface of the capsule, the thigh being slightly flexed (Fig. 112). This bursa may be demonstrated by injecting it with fluid or by introducing the index-finger through an incision into its wall.

Inflammation of this bursa being attended with pain upon motion at the hip-joint may thus simulate disease of the joint itself. A second bursa may be found under the psoas, extending upward to the lower limit of the iliac fossa.

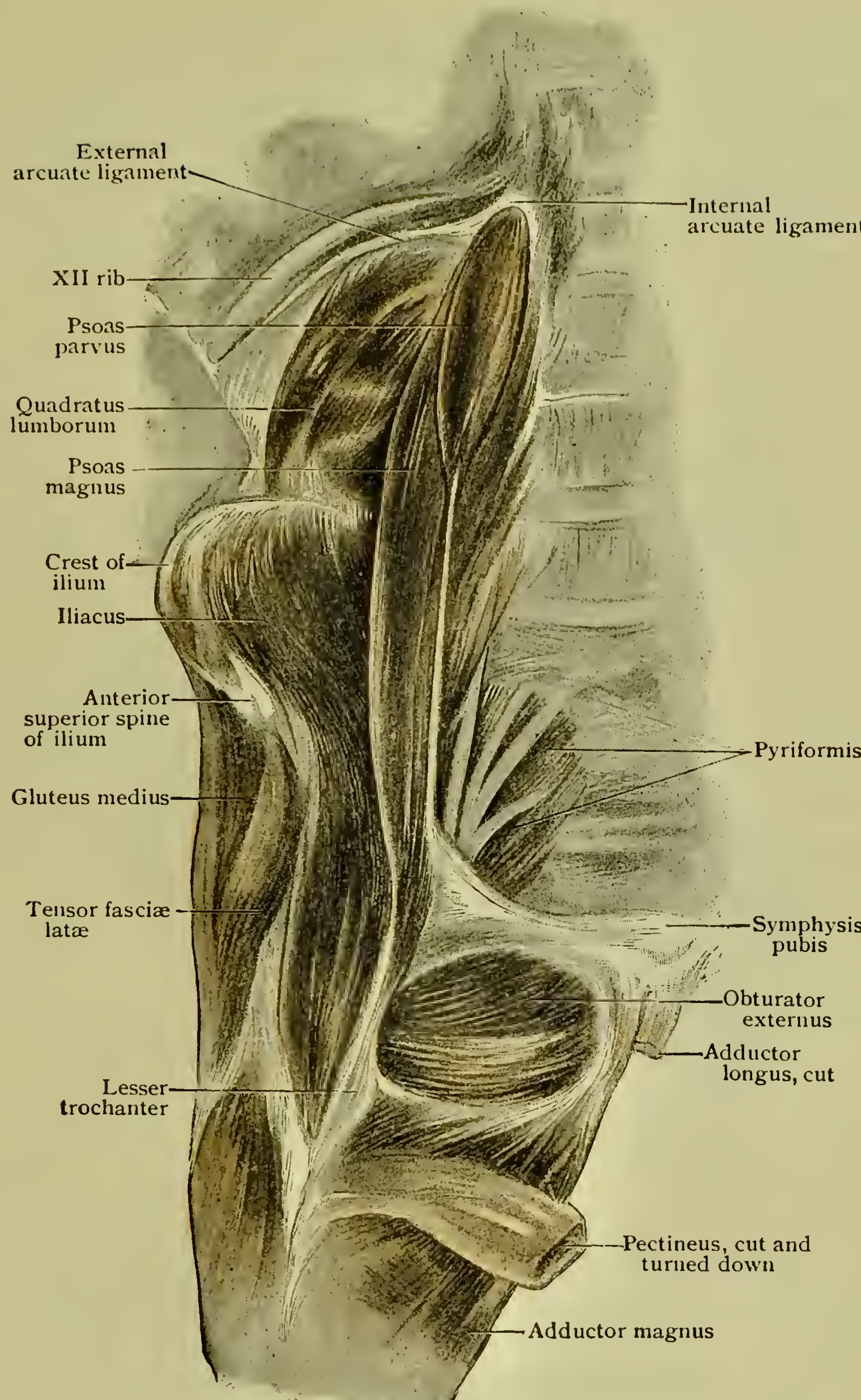

FIG. 111.—Deep dissection of posterior body-wall and iliac fossa of right side.

The iliacus and psoas should now be removed by dividing them near their insertion and reflecting them upward.

The anterior and lateral aspects of the capsule being now exposed, the vessels in relation with its inner aspect, branches of the obturator

artery and of the internal circumflex, should be inspected and fully dissected if this has not already been done.

The **capsule,** when cleared of extraneous tissue, will be seen to be attached to the cotyloid ligament,—which attachment will be more obvious upon the opening of the capsule (Fig. 114),—to the transverse ligament and to the bony rim of the acetabulum and the adjacent surface of bone; below, the capsule is attached to the anterior intertro-

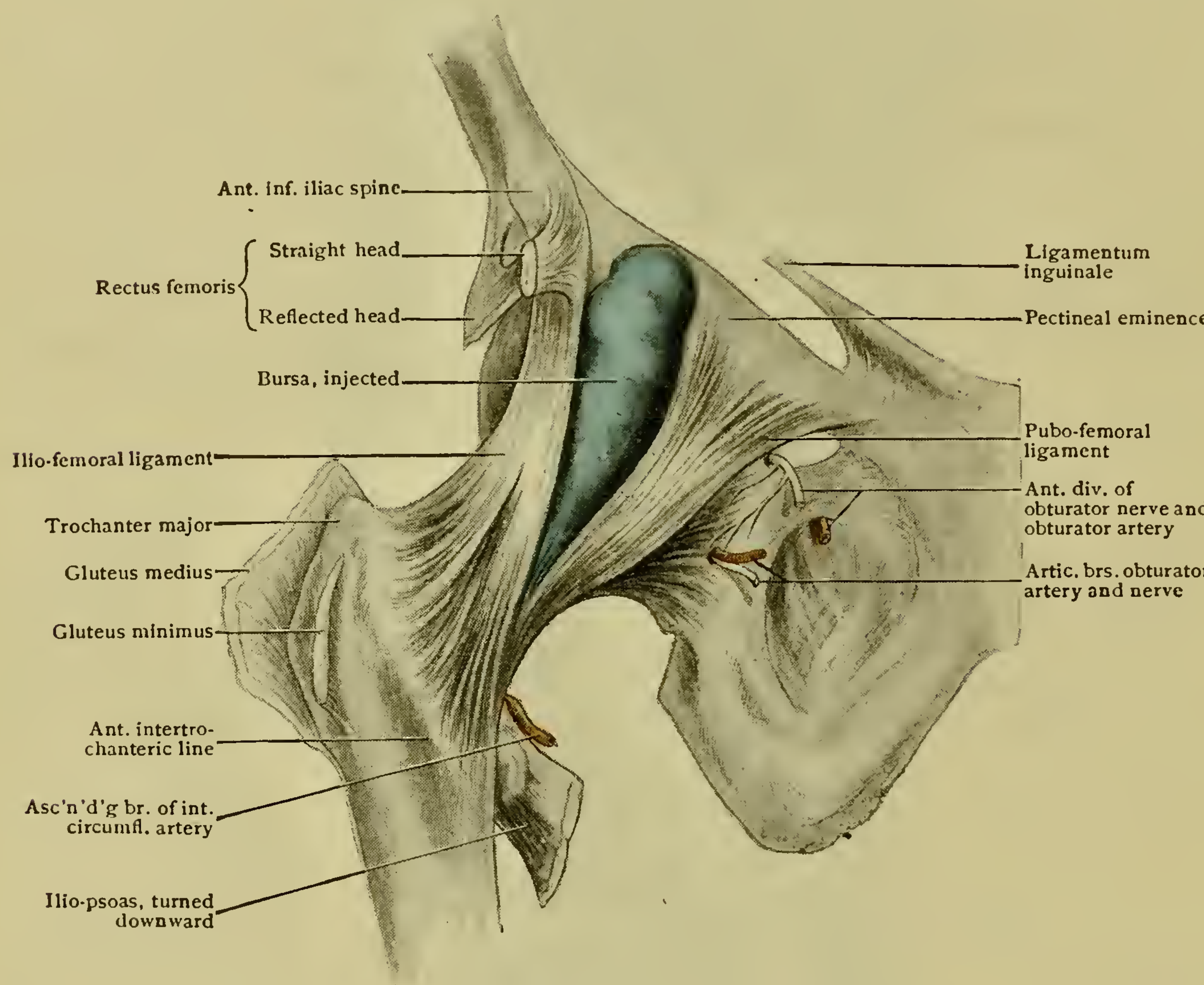

FIG. 112.—Dissection of anterior aspect of hip-joint.

chanteric line but falls short by a half inch of the posterior intertrochanteric line as its line of attachment crosses the posterior surface of the neck.

The **ilio-femoral ligament** (ligament of Biglow or Y-ligament), a localized thickening of the capsule (Fig. 112), should be examined, its attachment above to the anterior inferior spine of the ilium and by its lower bifurcated extremity to the two ends of the anterior intertrochanteric line being noted. This ligament by reason of its strength remains unruptured in any ordinary dislocation of the hip-joint, the so-called irregular dislocations being those in which there is extensive laceration of the capsule including the Y-ligament.

The **pubo=femoral ligament** (lig. pubocapsulare) is another thickening of the capsule which passes from the vicinity of the pectineal eminence downward and outward to the neck of the femur.

The **ischio=femoral ligament** (lig. ischiocapsulare) is a thickened portion of the posterior part of the capsule passing from the ischial portion of the acetabular rim toward the digital fossa (Fig. 113).

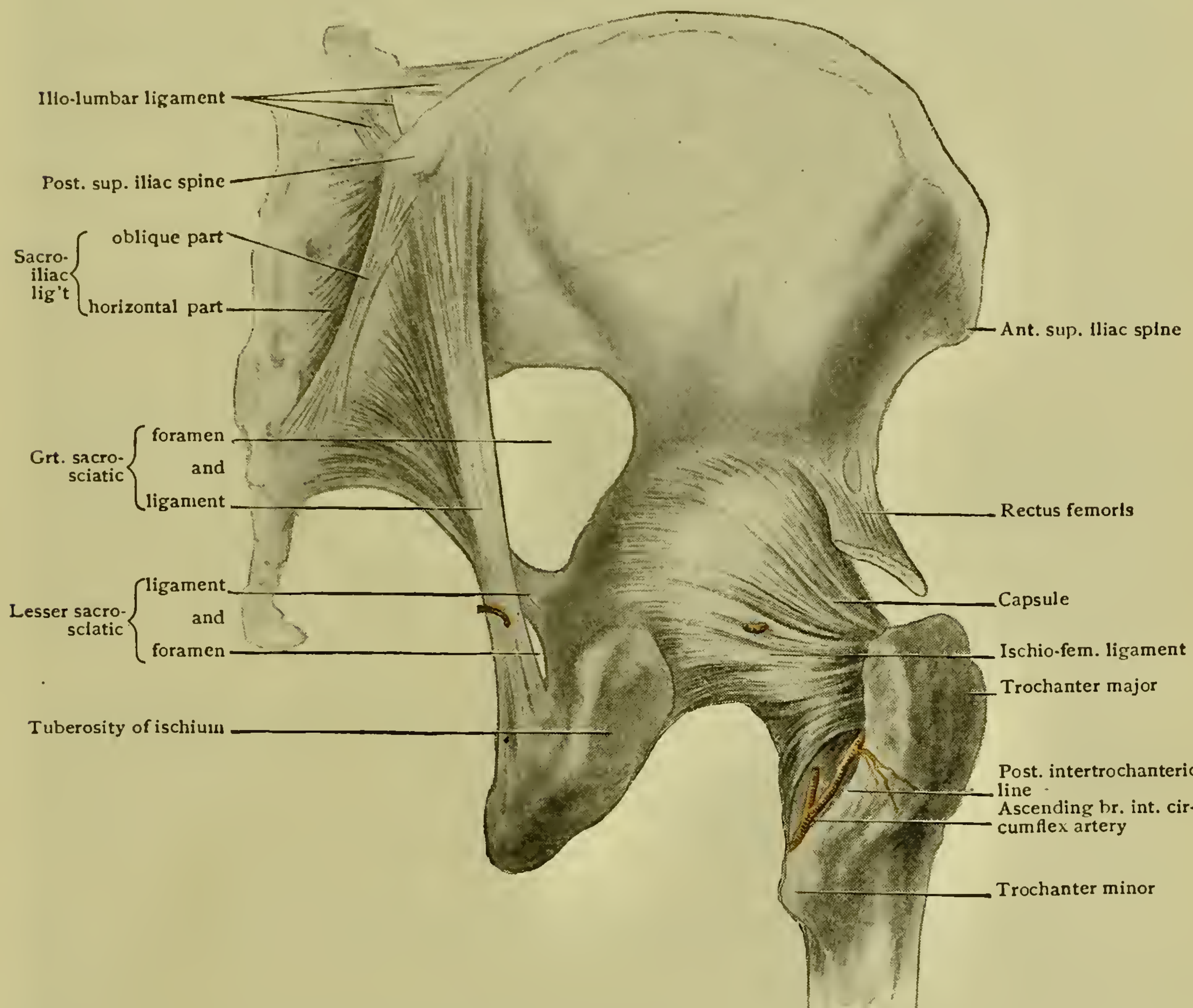

FIG. 113.—Dissection of posterior aspect of hip-joint and sacro-iliac and sacro-sciatic ligaments.

The weakest part of the capsule is its lower posterior portion; hence, in the regular luxations, whatever may be the subsequent position of the head of the bone, the latter leaves the acetabular cavity through a rent in this part of the capsule. The ultimate situation of the head is determined by the position of the femur at the moment of the application of the force which produces the luxation as well as by the direction in which that force is applied.

The Ischiatic Dislocation of the Femur. — The head is displaced backward upon the great sciatic foramen in this dislocation. This may be demonstrated by making an incision in the lower posterior

part of the capsule and forcing the head of the bone out of the acetabulum by grasping the thigh near the knee and near its upper extremity. Let the dissector now note the resulting alteration in the axis of the limb and in its length; thus there will be found to be inversion, adduction and moderate shortening, signs quite characteristic of this form of luxation.

The Dislocation upon the Dorsum of the Ilium. — The displacement backward and upward upon the dorsal surface of the ilium is the most common form of dislocation at the hip. The dissector may imitate this by grasping the thigh as before and manipulating the head of the femur into a position upon the dorsal surface of the ilium. Noting now the axis of the limb and its relative length, one finds the signs of the ischiatic luxation accentuated: more marked inversion, adduction and shortening, the great toe of the affected limb touching the instep of the opposite foot instead of the ball of its great toe as in the preceding case.

The reduction of these backward dislocations may be accomplished by flexing the thigh upon the abdomen in the position in which it was found, that is, in adduction, then sweeping the knee across the abdomen in the outward direction (external circumduction) and gradually bringing the limb down to a straight position. The Y-ligament in these manipulations serves as a fulcrum by which the head of the bone is returned to its proper cavity.

The Thyroid or Obturator Luxation.—If the dissector will now so manipulate the limb as to bring the head of the femur into relation with the obturator foramen, he will note that the signs of this dislocation are a slight lengthening of the limb in most cases, moderate abduction and moderate eversion, or, instead of eversion, the foot may be straight and there may be simply inability to produce inversion.

The Suprapubic Dislocation. — This extremely rare injury may be simulated by manipulating the head of the femur to the anterior surface of the pubis. The resulting alteration in the axis of the limb is a striking eversion, with abduction and shortening.

This combination of signs is seen also in fracture of the femoral shaft or neck, but the dislocation would be readily recognized by the presence of the head of the bone in its abnormal position; the extreme rarity of this injury and the immobility usually incident to luxation would aid further in the diagnosis.

The reduction of the forward displacements may be accomplished by again flexing the thigh in the position in which it was found—that is, in abduction—and then in performing internal circumduction and bringing the limb down to a straight position.

The exposure of the interior of the joint should now be effected by incising the capsule throughout its entire circumference near its attachment to the femur. The **ligamentum teres** is now brought fully to view

and its broad base of attachment to the bottom of the acetabulum as well as its much more circumscribed attachment to the depression upon the head of the femur should be noted (Fig. 114).

The line of reflection of the **synovial membrane** from the inner surface of the capsule to the neck of the femur may be followed as well as its continuation over the fat in the bottom of the acetabulum and around the ligamentum teres. One of the **retinacula** or **cervical ligaments,** bands and fibres derived from the capsule along the line of reflec-

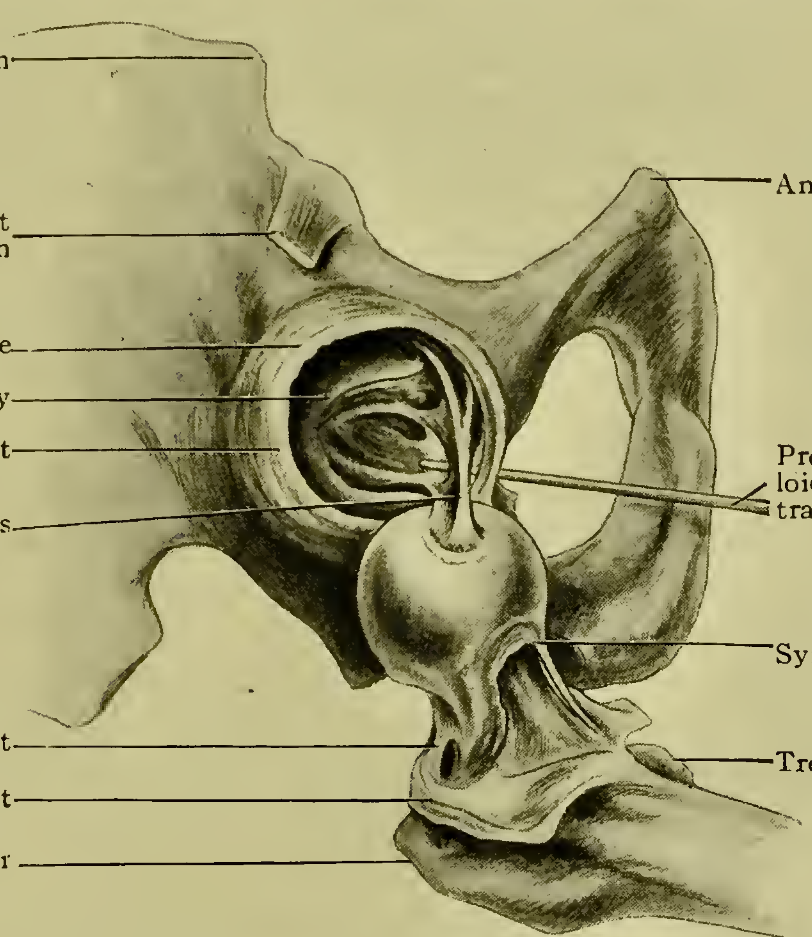

FIG. 114.—Hip-joint, antero-external view, with capsule cut and head of femur displaced to show acetabular cavity.

tion of the synovial membrane and passing along the neck of the bone toward its head, is seen in Fig. 114.

The ligamentum teres may now be divided and the limb removed from the trunk for further work.

The **cotyloid** and the **transverse ligaments** should be inspected and the proximity of the bottom of the acetabular cavity to the pelvic cavity should be noted.

The depth of the acetabular cavity and the corresponding extent of the articular surface of the head of the femur have a direct bearing not only upon the movements of this joint but upon its security; thus, while its range of motion is restricted as compared with that of the shoulder-joint, it is much more secure than the latter joint, dislocations being less frequent here than at the shoulder.

Coxalgia or *hip-joint disease*, in which the bony surfaces involved in this joint are affected, may result in the perforation of the bottom of the acetabular cavity, pus

thus finding its way into the pelvic cavity, or in the formation of external abscess. The bottom of the acetabular cavity may be *fractured*, the fracture being simple or comminuted, the latter form of injury often implicating the pelvic cavity.

Having completed the dissection of the thigh, the student should study the femur from the aspect of its structural peculiarities as bearing upon injury to and disease of the bone as well as the relations of the attached muscles and their influence upon the several fragments in case of fracture.

Fractures of the shaft of the femur occur most frequently at or near its middle. *Fractures of the upper third* are less common, are usually due to indirect violence and generally present an oblique line of fracture; the effect of the ilio-psoas in flexing the upper fragment has been referred to (p. 206). *Fractures of the lower third* are usually due to direct violence and in that case the line of fracture is transverse. These fractures present, in common, eversion of the limb below the fracture, due to its weight and to the action of the adductors, especially of the magnus and the gracilis; and shortening, as made evident by measurement and by the relaxation of the ilio-tibial band (p. 212), in addition, of course, to the cardinal signs of fracture, such as deformity, crepitus and mobility. *Supracondylar fracture* presents certain points of special interest in the matter of the tilting backward of the lower fragment by the pull of the gastrocnemius.

Fractures of the upper extremity include those of the head, neck and trochanters. *Epiphyseal separation of the head*, the epiphysis corresponding approximately with the part of the bone lodged in the acetabulum, occurs in children as a result of indirect violence (over-extension of the femur). *Fracture of the great trochanter* may be a true fracture or, when occurring prior to the nineteenth year, an epiphyseal separation; there is not usually much displacement because of the attachment of the joint-capsule to the bone below the epiphyseal line. *Epiphyseal separation of the lesser trochanter* is extremely rare.

Fractures of the neck have been classified as intra- and extracapsular fractures. While a fracture of the neck may be wholly within the limits of the capsule, no fracture of this part of the bone could be wholly extracapsular, for the reason that the capsule is attached in front to the anterior intertrochanteric line and the line of fracture would of necessity be within the capsule in front if it were a fracture of the neck. Fractures of the femoral neck occur in advanced life, especially of the intracapsular variety, and may be produced by trifling causes—such as turning over in bed—owing to the absorption of the cancellous tissue of the bone and the thinning of the compact tissue incident to old age. The fractures may be *impacted*. Consideration of the muscles inserted into the greater trochanter (external rotators) will suggest at once the eversion of the limb which is characteristic of these fractures; what was

said of shortening and of relaxation of the ilio-tibial band in connection with fractures of the femoral shaft is equally applicable here. The use of Nélaton's line and of Bryant's line or Bryant's ilio-femoral triangle in determining shortening has been referred to (p. 163).

Fractures of the lower extremity include epiphyseal separation, intercondylar fracture and T-fracture. *Epiphyseal separation* may occur before the age of twenty. Although the lower epiphysis of the femur is among the earliest, if not the earliest, to show beginning ossification, it unites with the diaphysis after the union of the upper epiphyses. Note, in this connection, the upward direction of the nutrient canal, the orifice of which is near the middle of the linea aspera. In this lesion the popliteal vessels are apt to suffer severely, being injured by the lower end of the upper fragment. The vessels are equally liable to damage in the *intercondylar* and *T-fractures*.

The **lower epiphyseal line** of the femur should be noted, since, the chief growth of the bone in length depending upon the lower epiphysis, it is important to avoid trespassing upon this line on operations upon the immature bone—as in osteotomy for knock-knee or for bow-legs—if interference with the growth of the bone is to be avoided. The epiphyseal line is on a level with the adductor tubercle internally but at a slightly higher level on the outer side of the bone.

Among the **diseases** to which the femur is liable are *inflammations*, of an infective nature, *tumors*, such as sarcoma occurring most commonly at the lower end of the bone (compare p. 90), *exostoses*, and *deformity at the lower end*, usually due to rickets, and producing either bow-legs (genu varum) or knock-knee (genu valgum).

THE ANTERIOR SURFACE OF THE LEG.

As a preliminary to the dissection of the leg, the bones of the member should be reviewed.

The Tibia.—The **upper extremity** or **head** of the tibia presents an *outer* and an *inner tuberosity*, the superior surfaces of which show each a *condylar articular surface* for the respective condyles of the femur, with the *spine* (eminentia intercondyloidea) projecting upward between them. The tuberosities are continuous in front and present the *tubercle* (tuberositas tibiæ) for the anterior ligament of the knee, while they are separated behind by the *popliteal notch* (fossa intercondyloidea posterior). Note the *articular facet* for the fibula on the lower back part of the outer tuberosity and the transverse groove or impression on the posterior surface of the inner tuberosity for the insertion of the semimembranosus.

The **shaft,** triangular in cross-section, should be noted as presenting an *anterior border* or *crest* (crista anterior), a less well marked *inner*

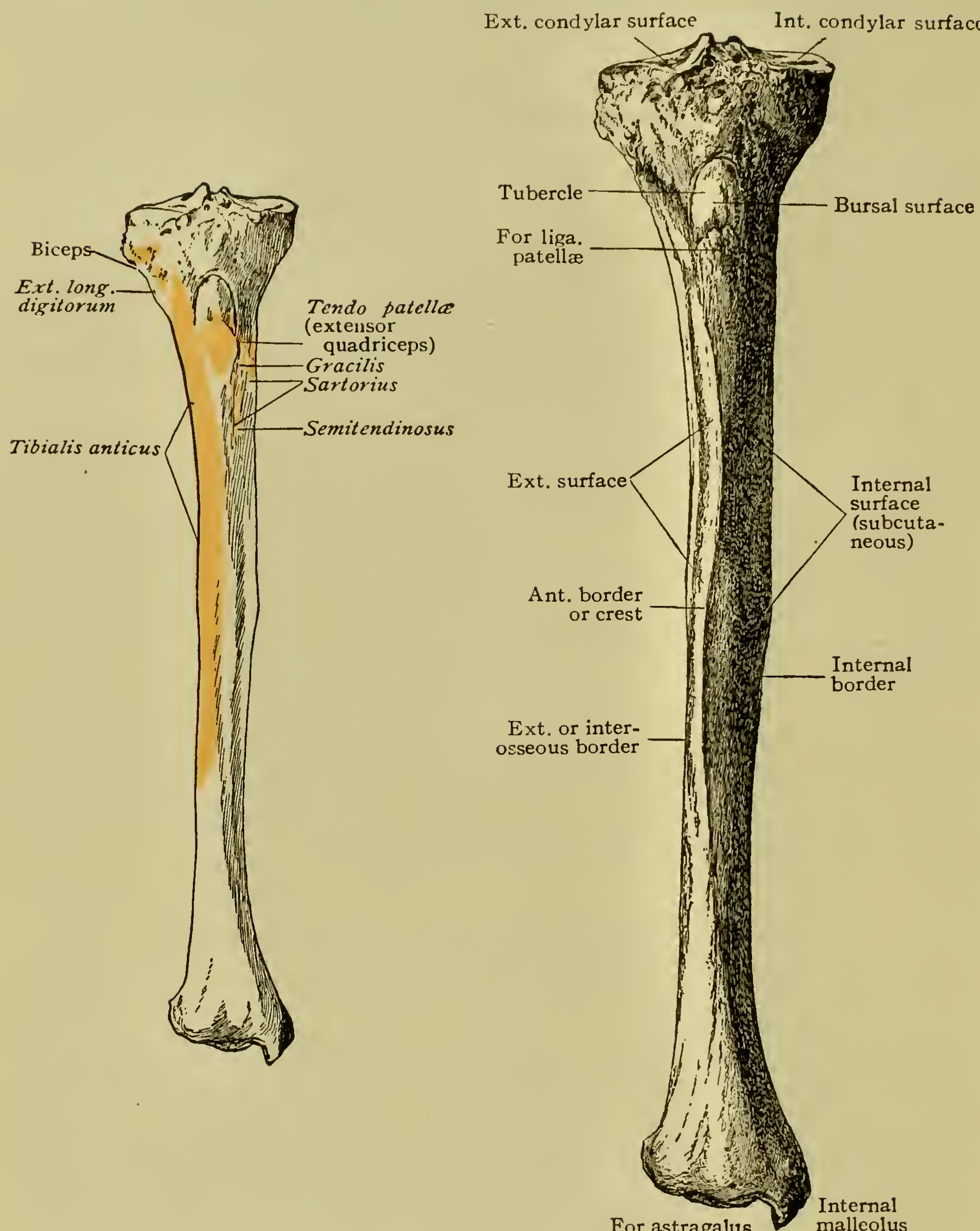

FIG. 115.—Right tibia from before. The outline figure shows the areas of muscular attachment.

border and an *outer* or *interosseous border* (crista interossea), separating the *inner*, *outer* and *posterior surfaces*. The posterior surface (Fig. 116) is especially noteworthy as presenting the oblique line above (linea poplitei) and the division of the surface of bone below it into two muscular areas by a vertical ridge.

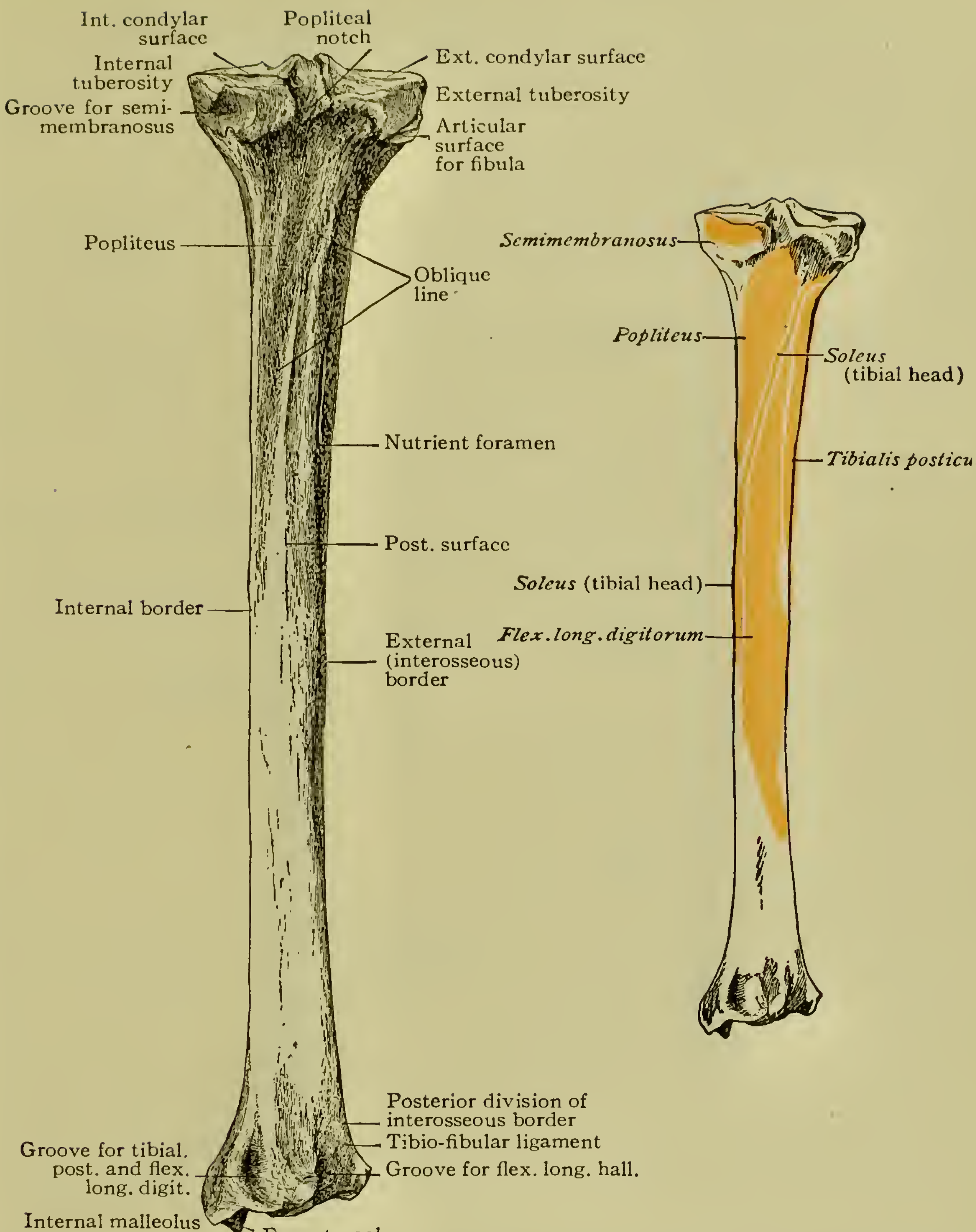

FIG. 116.—Right tibia from behind. The outline figure shows the areas of muscular attachment.

The **lower extremity** has the conspicuous *inner malleolus*, in front of which is the lower end of the anterior border of the bone, while behind it is the termination of the inner border; the *inferior articular surface*, continuous with the articular surface on the inner malleolus; a *triangular, partly articular surface* on the outer aspect embraced by the bifurcated

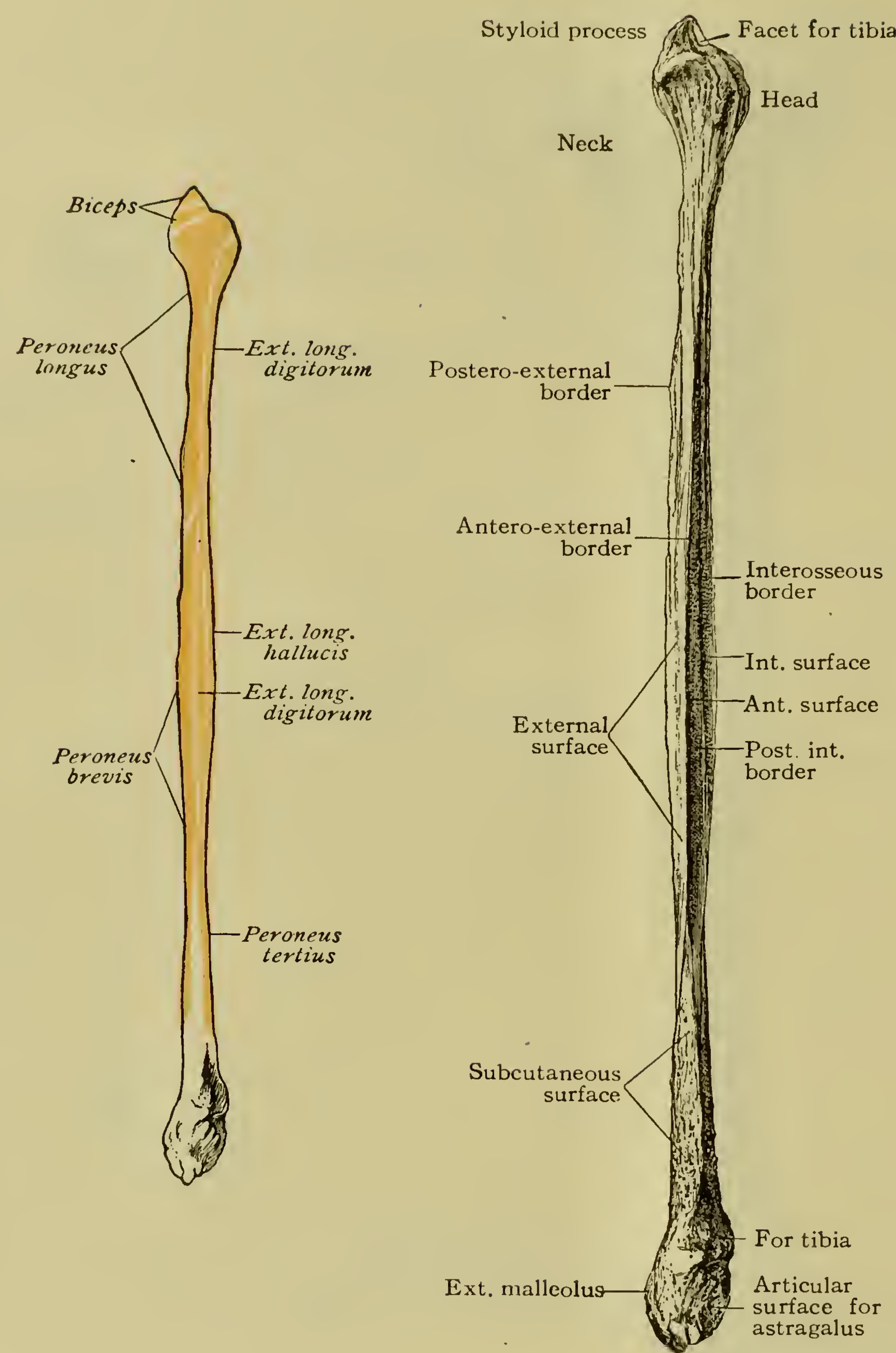

FIG. 117.—Right fibula from before. The outline figure shows the areas of muscular attachment.

lower ends of the external border of the bone; and *two grooves* on the posterior surface for tendons (Fig. 116).

The Fibula.—At the **upper extremity** of the fibula, the *head* with its *styloid process* and *articular facet* will be noted. The **shaft** is usually described as being quadrilateral on cross-section, but the irregularity of

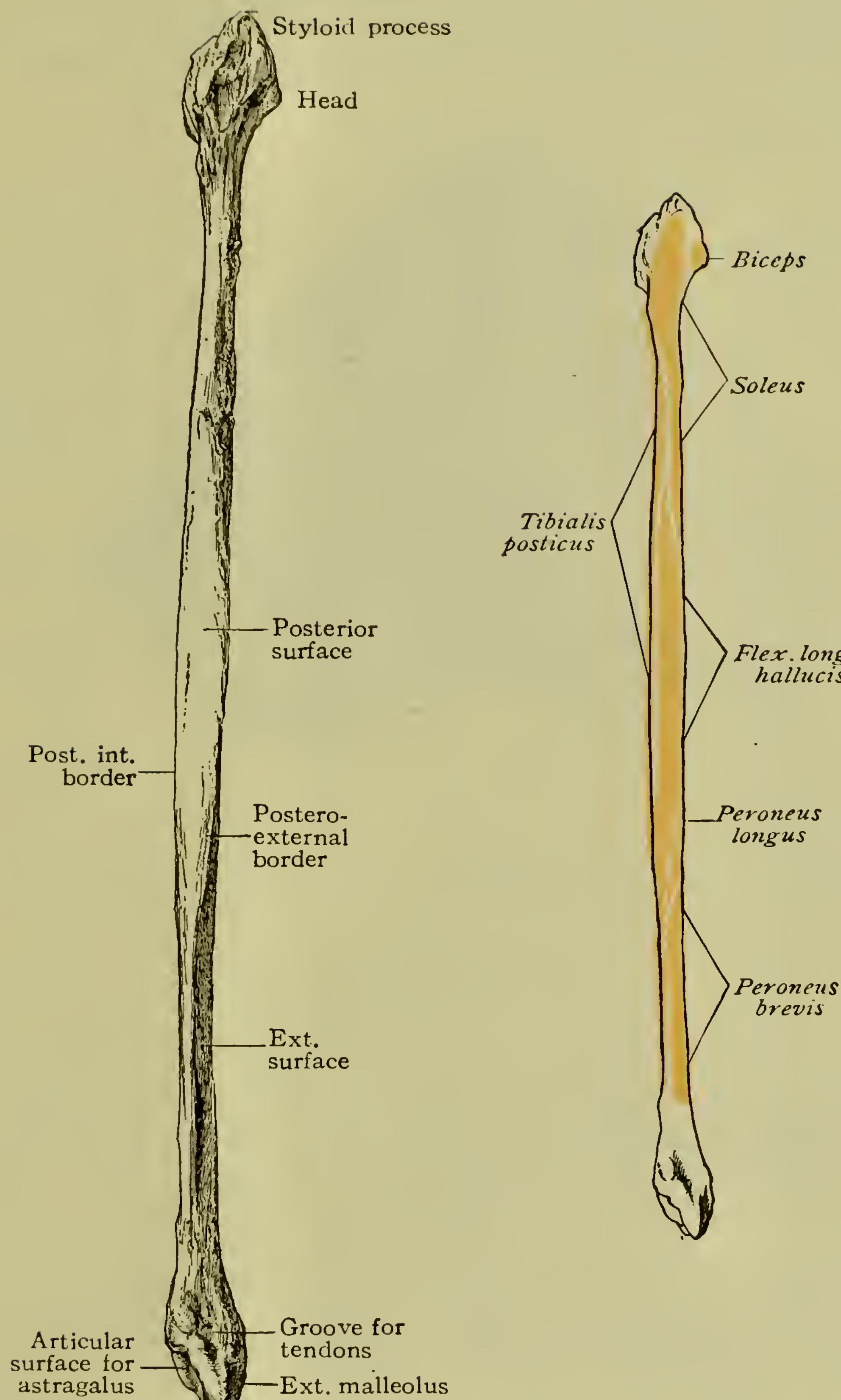

FIG. 118.—Right fibula from behind. The outline figure shows the areas of muscular attachment.

the *four borders* and *four surfaces* in most cases makes them difficult to follow. It is helpful to recognize the fact that the *anterior surface* is in the same vertical plane as the external border of the tibia (Fig. 119), the interosseous membrane connecting the external or interosseous border of the tibia with the *antero-internal border* of the fibula. Refer-

ence to Fig. 119 will show the relations of the various groups of muscles to the several surfaces and of the fascial septa to the borders.

The **lower extremity** constitutes the *outer malleolus*, the external surface of which is subcutaneous, while the internal surface is largely articular.

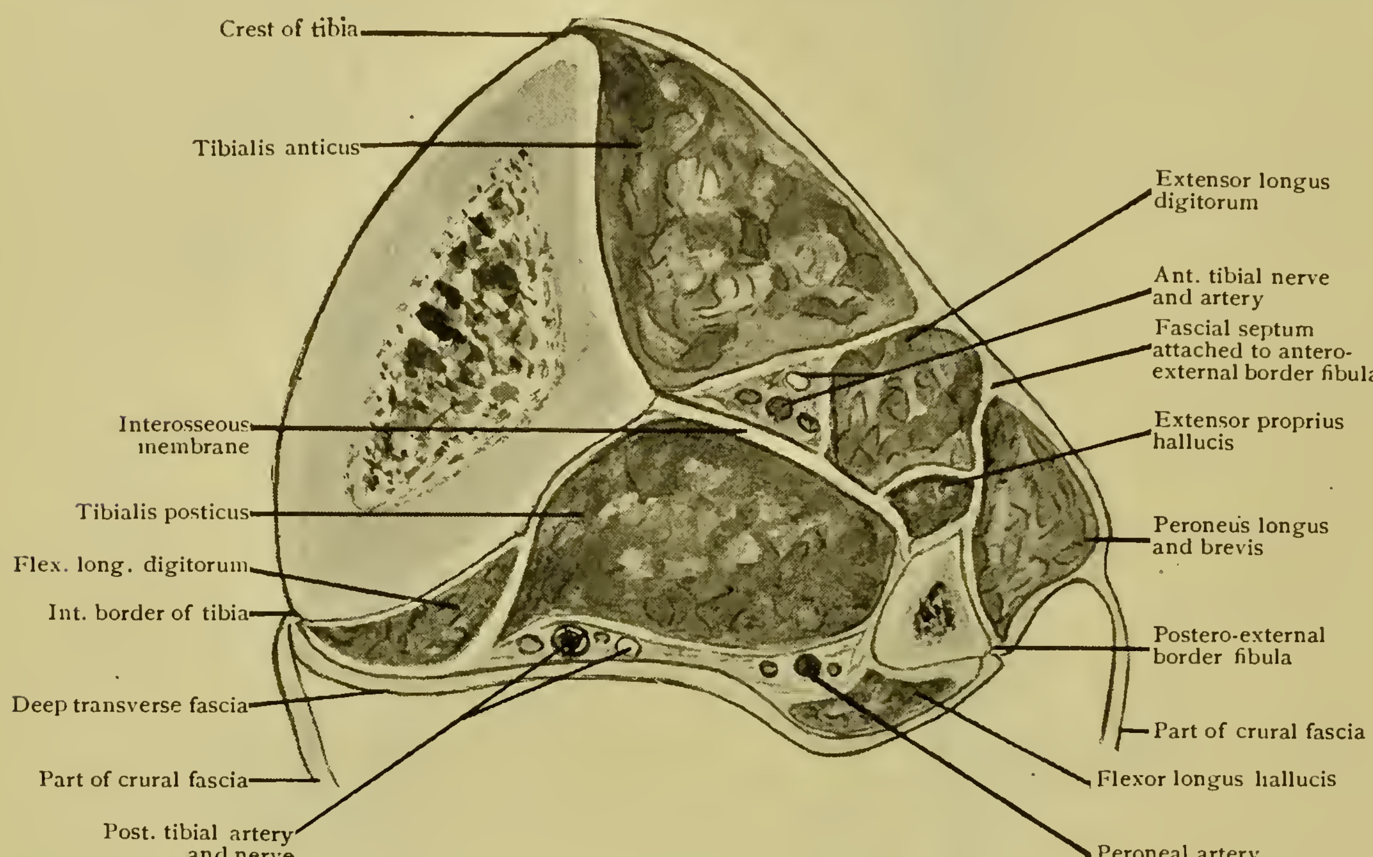

FIG. 119.—Diagram of cross-section through right tibia and fibula at the middle of the leg to show the relative positions of the bones and the relations of the fascial septa.

THE SURFACE ANATOMY.

The bony prominences in the neighborhood of the knee and their significance have already been pointed out (page 208). From the **tubercle of the tibia** the finger readily traces downward the anterior border or **crest** of this bone, known popularly as the shin bone. This crest is subcutaneous, except in its lower fourth or fifth where a few tendons lie in front of it. The **inner surface of the tibia** is likewise easily felt, being subcutaneous, *i.e.*, covered only by skin, superficial fascia and periosteum. The **posterior border** of the bone, marking the posterior limit of the inner surface, is also readily followed from the position of the **internal tuberosity** above downward to the **internal malleolus** or inner ankle. The **head of the fibula** at the outer side of the leg, above, is easily palpable and the upwardly projecting **styloid process** at the back of the head may also be recognized. Below the head of the fibula the bone is palpated with difficulty by reason of the relation of the muscles which obscure it, except in the lower third of the leg, where the bone is again easily recognizable and may be followed downward to the **external malleolus** or outer ankle. Upon the outer side of the crest

of the tibia the muscular mass made up of the extensors and peroneal muscles gives a somewhat rounded contour to this part of the leg, this mass giving way in the lower third to the tendons of these various muscles which pass to the dorsal surface of the foot (Fig. 96).

DISSECTION.

A longitudinal incision from the tubercle of the tibia downward along the crest to the middle of the intermalleolar space, that is, the space in front between the inner and outer ankles, and a transverse incision just below the ankle should be made. Two skin-flaps should be reflected from the median incision (Fig. 97).

The Superficial Fascia.—The superficial fascia of the leg presents no special features except as to its contents. On the outer side in the upper part will be found the terminations of the cutaneous patellar branch of the internal saphenous nerve (Fig. 120) and a little lower down another branch or two of the internal saphenous crossing from the inner side of the leg, and cutaneous filaments of the **sural branch** of the peroneal nerve coming around the outer side from the posterior aspect. In the lower third, on the outer side, lying rather beneath the superficial fascia than within it, will be found the **musculo=cutaneous nerve,** which pierces the deep fascia at the junction of the middle and lower thirds of the leg about one and one half inches external to the crest of the tibia. This divides into two branches (page 248) which pass downward to the dorsum of the foot and which may give off some cutaneous filaments to the lower third of the leg.

The **internal saphenous vein,** originating in a venous plexus on the dorsum of the foot, passes in front of the inner malleolus and up the inner side of the leg behind the inner condyle of the femur, then up the inner and anterior aspects of the thigh to terminate in the femoral vein, as previously noted (page 196). It should be denuded throughout its course. It receives many tributaries, but none of any special significance.

This vein, by reason of its length and its superficial situation, is prone to become varicose, that is, dilated and elongated, in which many of its tributaries participate, constituting the rather common condition known as *varicose veins of the leg.*

The **internal saphenous nerve,** consisting of one or two trunks, runs in close relation with the vein and should be followed from the upper part of the leg to the point where it enters the foot. Its further course along the inner side of the foot, the skin of which it supplies as far as the ball of the great toe, will be followed in the dissection of the foot.

The **superficial branch of the anastomotica magna artery** (page 220), keeping close company with the internal saphenous vein and nerve, should be dissected in connection with these two structures. The

cutaneous branch of the obturator nerve (page 219) may be found along the inner side of the leg. What remains of the superficial fascia may now be removed to expose the deep fascia.

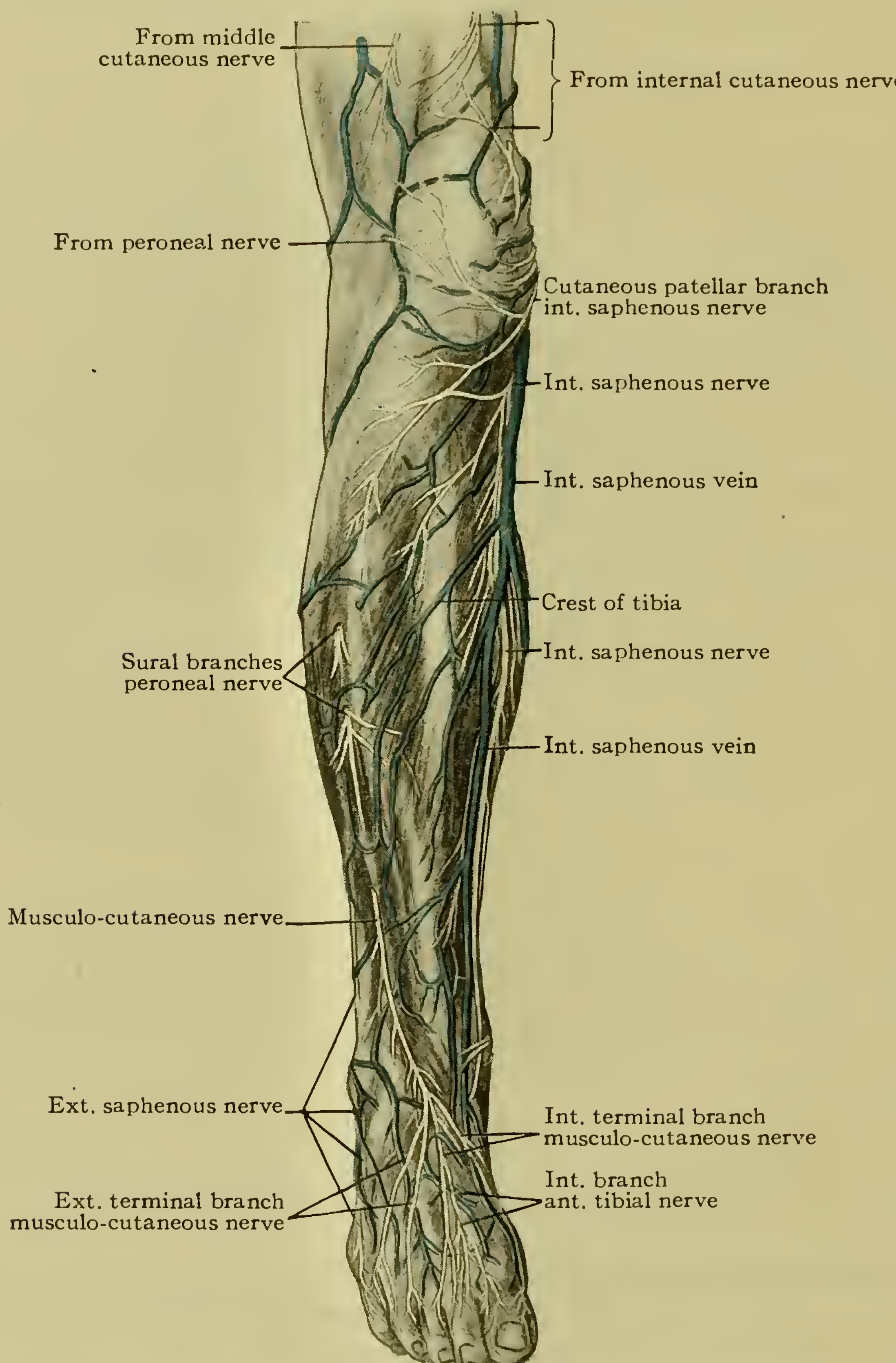

FIG. 120.—Superficial dissection of anterior surface of leg and dorsum of foot.

THE DEEP FASCIA (crural fascia).—The deep fascia of the leg, a well-developed aponeurotic structure, is attached to the bony prominences in the neighborhood of the knee, to the crest of the tibia and

to the inner and outer malleoli. Between the two malleoli it presents a thickening, the *vertical portion* (ligamentum transversum cruris) of the **anterior annular ligament** (Fig. 121), which serves to bind down

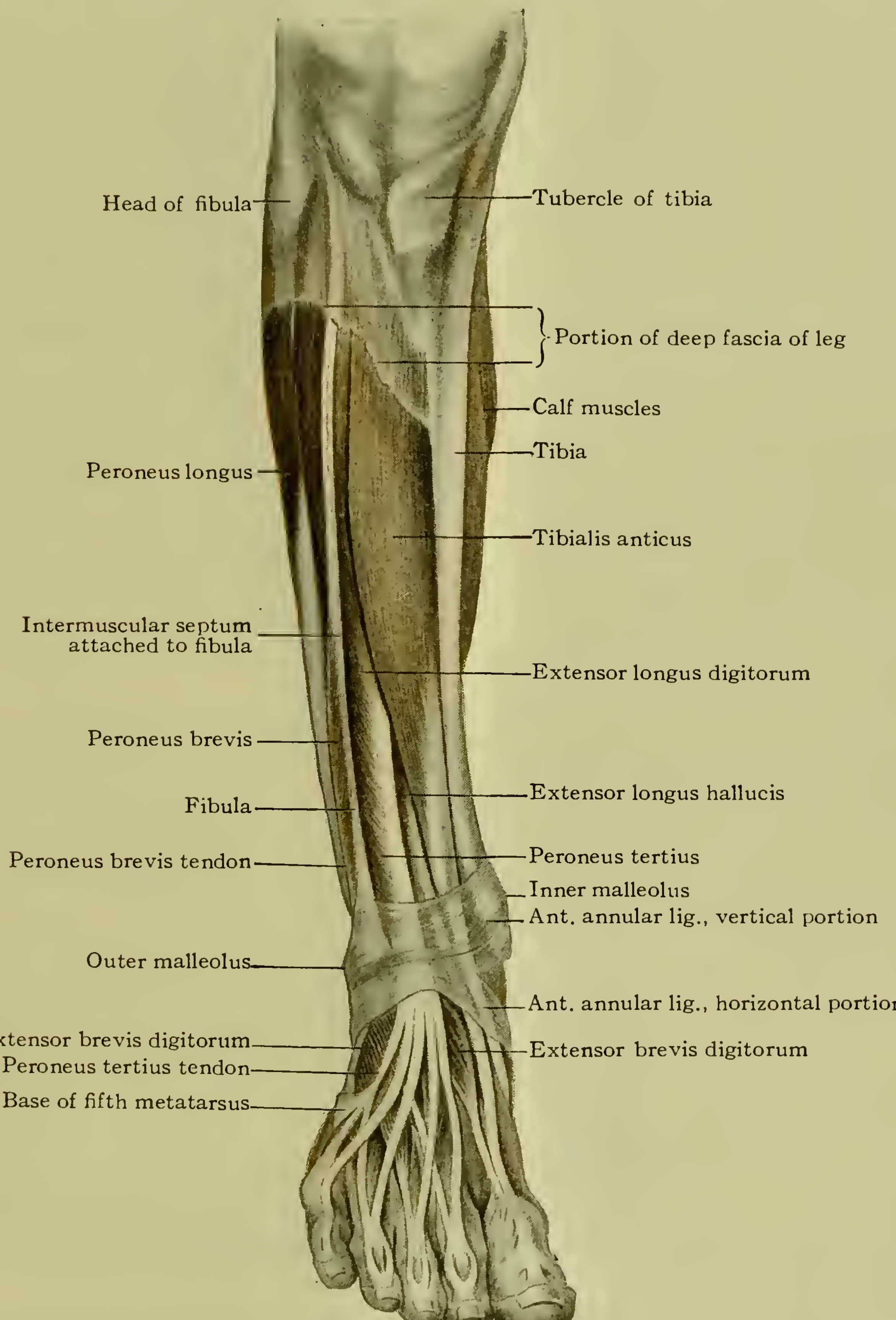

FIG. 121.—Superficial dissection of anterior surface of right leg, showing muscles undisturbed.

the tendons as they pass to the dorsum of the foot. The *horizontal portion* of the latter (ligamentum cruciatum) will be encountered in the dissection of the dorsum of the foot. The vertical part of the liga-

ment, attached to the tibia and fibula at their lower ends, has beneath it a fibrous canal for the tendons of the extensor proprius hallucis and extensor longus digitorum, and internal to this a second compartment for the tibialis anticus tendon. Behind the outer malleolus is also a thickened band of the deep fascia, the **external annular ligament** (retinacula m. peronæorum), serving to bind down the tendons of the peroneus longus and brevis. The **internal annular ligament,** another thickening of the crural fascia, will be met with in dissecting the posterior surface of the leg (p. 264). Several **septa** of the deep fascia are attached respectively to the antero-external border of the fibula, separating the tibial group of muscles from the fibular group, and to the postero-external border of the same bone, separating the fibular muscles from the posterior muscles; a still more important septum, the **deep transverse intermuscular septum,** is considered on page 263.

A vertical incision should now be made through the deep fascia along the outer side of the crest of the tibia terminating below in front of the inner malleolus. Reflecting outward a flap of the deep fascia the tibial group of muscles will be exposed (Fig. 121). The internal and external malleolar arteries, branches of the anterior tibial (Fig. 123), should be sought a few inches above the malleoli and should be traced to their terminations. The anterior tibial recurrent artery (page 222) which passes upward and outward from near the tubercle of the tibia has already been isolated.

The Tibialis Anticus (Fig. 121).—**Origin,** the upper two thirds or three fourths of the outer surface of the shaft of the tibia and the adjacent portion of the interosseous membrane as well as from the deep surface of the deep fascia; **insertion,** the internal cuneiform bone and the base of the first metatarsal bone on the inner side; **nerve-supply,** the anterior tibial nerve (fourth and fifth lumbar and first sacral); **action,** dorsal flexion and inversion of the foot.

A yellowish line will mark the interval between this muscle and the long extensor of the toes on its outer side. Separating the muscle from its neighbor, removing cellular tissue and tracing the muscle downward, it will be seen to terminate in a tendon which passes through its own canal under the innermost part of the anterior annular ligament. In separating the muscle from the extensor longus digitorum on its outer side, care should be exercised on account of the anterior tibial nerve and artery which are situated deeply between these two muscles in the upper third of the leg.

The Extensor Longus Digitorum. — **Origin,** the upper three fourths of the anterior surface of the shaft of the fibula, the outer tuberosity of the tibia, the interosseous membrane and the deep fascia (Fig. 122); **insertion,** by four tendons into the second and third phalanges of the four lesser toes, the three inner tendons being joined on their outer

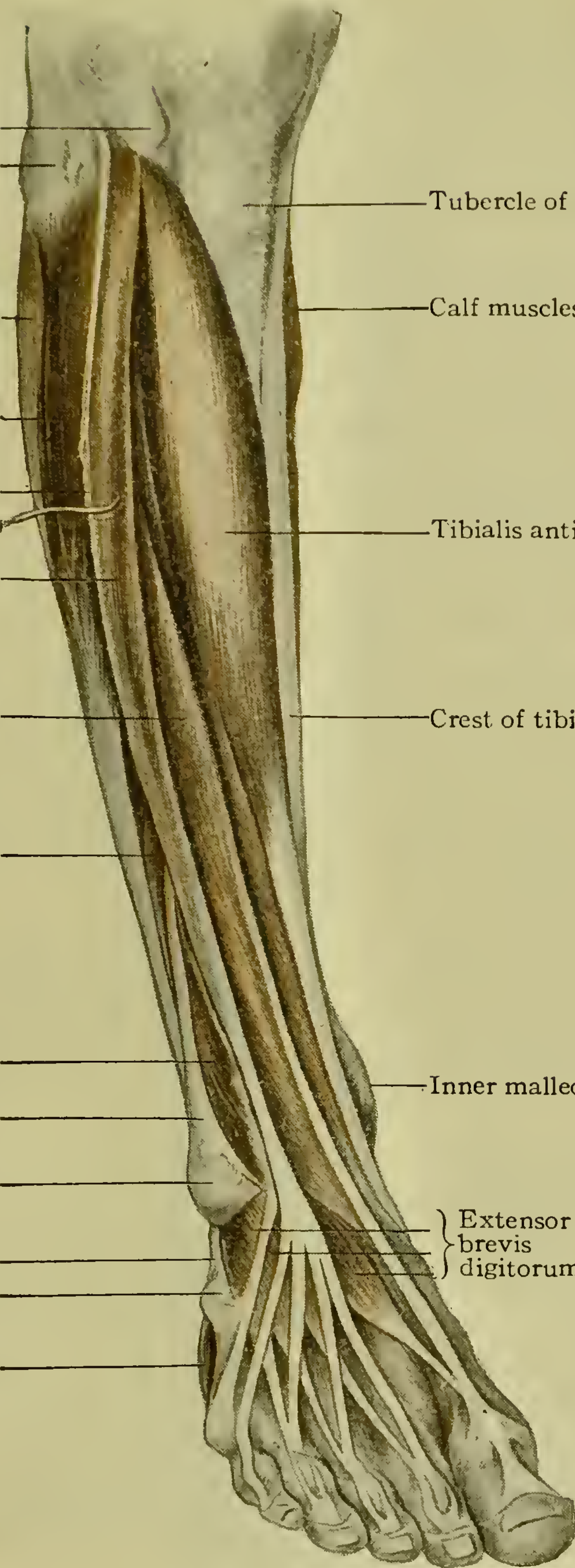

FIG. 122.—Muscles of anterior surface of right leg; extensor longus digitorum has been drawn aside to expose extensor longus hallucis.

sides by the corresponding tendon of the short extensor and all receiving the insertions of the interossei and lumbricales; **nerve=supply,** the anterior tibial nerve (fourth and fifth lumbar and first sacral); **action,** extension of the four lesser toes and dorsal flexion of the foot.

THE PERONEUS TERTIUS (Fig. 122).—**Origin,** the lower fifth of the

anterior surface of the fibula, the interosseous membrane and crural fascia; **insertion,** the dorsal surface of the proximal extremity of the fifth metacarpal bone; **nerve=supply,** the anterior tibial nerve (fourth and fifth lumbar and first sacral); **action,** elevation of the outer side of the foot, *i.e.*, flexion and eversion.

These two muscles are frequently so closely united as to appear as one. Their surfaces should be cleaned and the position of their tendons under the anterior annular ligament noted as occupying the same compartment with the extensor proprius hallucis.

Undue contraction or shortening of this group of muscles, resulting from infantile paralysis, pre-natal or post-natal, or from any other cause, drawing up the foot into dorsal flexion, is responsible for the variety of club-foot known as *talipes calcaneus*, in which the patient walks on the heel or calx. If only the tibialis anticus is affected or if the tibialis anticus in conjunction with the tibialis posticus, the foot is inverted, the patient walking on the outer edge of the sole; this is *talipes varus*.

The Extensor Proprius Hallucis (extensor hallucis longus).—**Origin,** the middle two fourths of the anterior surface of the shaft of the fibula and the interosseous membrane; **insertion,** the first and second phalanges of the great toe; **nerve=supply,** the anterior tibial nerve (fourth and fifth lumbar and first sacral); **action,** extension of the great toe (Fig. 122).

The fleshy part of this muscle should be dissected and its tendon followed to the annular ligament, the tendon itself being left for dissection with the dissection of the dorsum of the foot, at which time its relation to the innermost tendon of the short extensor of the toes will be seen (p. 256).

Each of the three muscles just considered should be carefully isolated by blunt dissection, the separation of the anterior tibial muscle from the long extensor of the toes in the upper third of the leg revealing the anterior tibial artery with its two venæ comites and the anterior tibial nerve. As the muscles are cautiously pulled aside, numerous small muscular branches of the artery will be encountered as well as the muscular branches of the nerve. Working downward toward the ankle, the artery and nerve will be found, in the middle third of the leg, between the tibialis anticus and extensor proprius hallucis and still farther down between the latter muscle and the extensor longus digitorum.

The Anterior Tibial Artery.—This vessel, **originating** as one of the terminal branches of the popliteal artery in the lower part of the popliteal space at the lower border of the popliteus muscle and reaching the front of the leg by passing through the interosseous space above the interosseous membrane (Fig. 134), **terminates** at the bend of the ankle as the dorsalis pedis artery (Fig. 123). The **surface line** indicating its course is from the inner side of the head of the fibula to a

point midway between the two malleoli. Its **branches** are the *posterior recurrent tibial*, an inconstant branch arising on the posterior surface of the leg (Fig. 148), going to the popliteus muscle and the su-

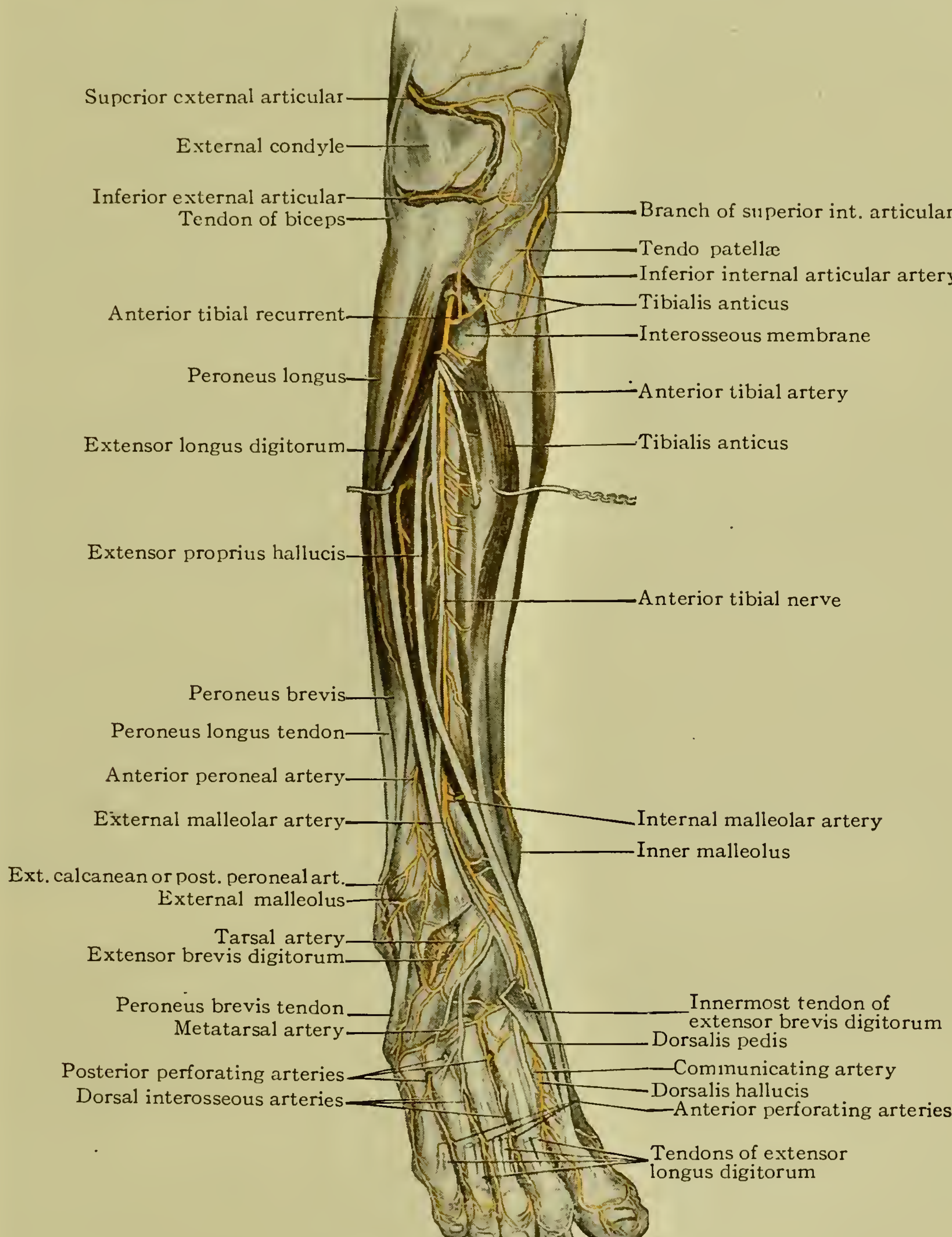

FIG. 123.—Dissection of front of leg and dorsum of foot.

perior tibio-fibular joint; the *superior fibular*, also inconstant, sometimes being a branch of the posterior tibial, arising posteriorly and passing outward beneath the soleus to end in the peroneus longus after

curving around the fibula; the *anterior recurrent tibial* (p. 222 and Fig. 147); *muscular* and *cutaneous* branches; the *internal malleolar* and the *external malleolar*.

The artery in the beginning of its course should be sought in the upper third of the leg between the tibialis anticus and the extensor longus digitorum muscles. Separating these muscles the vessel will be found at a considerable depth in close association with the interosseous membrane, with the anterior tibial nerve upon its outer side and with two accompanying veins (Fig. 123). These veins cling so closely to the artery that separation of them without injury to any of the structures is somewhat difficult and requires care. The **anterior tibial recurrent** branch, which has been already dissected (p. 222), arises from the upper part of the anterior tibial just as it reaches the front of the leg and passes upward and outward, becoming more superficial, to ramify on the outer aspect of the knee-joint, to which it gives some branches, anastomosing with the articular branches of the popliteal and with the other vessels which enter into the circumpatellar anastomosis (p. 221). Tracing the anterior tibial downward some of the **muscular branches** will be encountered. In the middle third of the leg the artery lies in the interval between the tibialis anticus and the extensor proprius hallucis. Separating these muscles the artery will be found at a less depth than above, with the anterior tibial nerve lying in front of it. In the lower third of the leg the vessel lies between the extensor proprius hallucis and the extensor longus digitorum, the former muscle having crossed the vessel; here the anterior tibial nerve lies to its outer side. The branches encountered here, in addition to **muscular branches,** are the **internal** and **external malleolar,** which should be traced successively as they pass inward and outward respectively. Tracing the artery downward, it will be seen to pass under the anterior annular ligament to continue as the dorsalis pedis artery.

The Relations of the Anterior Tibial Artery.—The relations of the vessel, although fully indicated above, may be repeated here in more concise form: the anterior tibial nerve is on the outer or fibular side of the artery except in the middle third where it lies in front; there is an accompanying vein on each side of the artery; in the *upper third of the leg*, the vessel is between the tibialis anticus and the extensor longus digitorum and is deeply placed upon the interosseous membrane (Fig. 123); in the *middle third*, it lies between the tibialis anticus and the extensor proprius hallucis; in the *lower third*, it is between the extensor proprius hallucis and the extensor longus digitorum, having been crossed by the former muscle, and rests upon the tibia.

From a study of the relations of the anterior tibial artery it is apparent that the most inaccessible portion of the vessel is the upper third and that its ligation would therefore be more difficult here than lower down in the leg.

The anterior tibial recurrent, by its inosculations with the branches of the femoral and popliteal (p. 222), becomes an important agent in establishing the collateral circulation after ligation of the popliteal artery, while the communications between the branches of the anterior tibial and those of the posterior tibial and peroneal are brought into service after ligation of the anterior tibial itself.

The anterior tibial artery may **vary** in its *course*, inclining toward the fibular side of the leg; or in its *size;* or it may be *absent*, its place being supplied by branches from the arteries on the posterior aspect of the leg.

The **anterior peroneal artery,** a branch of the peroneal, comes forward through the interosseous membrane in the lower third of the leg about two inches above the outer malleolus (Fig. 123); it should be exposed by displacing the peroneus tertius and should be traced to the outer malleolus. Its termination on the front and outer aspect of the tarsus may be worked out at a later stage of the dissection.

THE ANTERIOR TIBIAL NERVE (n. peronæus profundus).—The anterior tibial nerve, one of the terminal branches of the external popliteal or peroneal or fibular nerve, reaches the interval between the tibialis anticus and the extensor longus digitorum by passing beneath the upper part of the latter muscle and of the peroneus longus, from its point of origin below the outer aspect of the head of the fibula. The trunk of the nerve has been encountered and dissected in dissecting the anterior tibial artery when its relation to this vessel and to the interosseous membrane (p. 244) were noted. The course of the nerve around the outer side of the fibula will be seen upon dissection of the peroneus longus.

The **branches** of the nerve are the *muscular*, to supply the anterior tibial group of muscles, *i.e.*, the tibialis anticus, the extensor longus digitorum, the extensor proprius hallucis and the peroneus tertius; an *articular branch* to the ankle-joint; and the *internal* and *external terminal branches.*

These branches should now be sought and followed to their termination: The *branch to the tibialis anticus* includes an *upper twig* which, arising near the origin of the anterior tibial nerve (Fig. 124) and passing therefore beneath the peroneus longus and the extensor longus digitorum to reach the upper part of the tibialis anticus, is not entirely accessible until the peroneus longus is dissected; and a *lower branch* which enters the muscle at about the middle of the leg. The *branch to the extensor longus digitorum*, arising just below the origin of the preceding nerve, enters the deep surface of the upper part of its muscle (Fig. 124). The *nerve to the extensor proprius hallucis* arises near or above the middle of the leg and may consist of two parts. The *nerve to the peroneus tertius* usually branches off from that of the extensor longus digitorum. The *articular branch* is usually given off near the ankle-joint and enters the joint in front (Fig. 153). The *terminal branches* belong to the dissection of the foot (p. 253).

The fibular muscles must now be exposed by reflecting the overlying layer of deep fascia, having regard for the musculo-cutaneous nerve where it perforates this fascia (Fig. 120).

THE PERONEUS LONGUS (Fig. 125).—**Origin,** the upper two thirds or three fourths of the outer surface of the fibular shaft; **insertion,** the

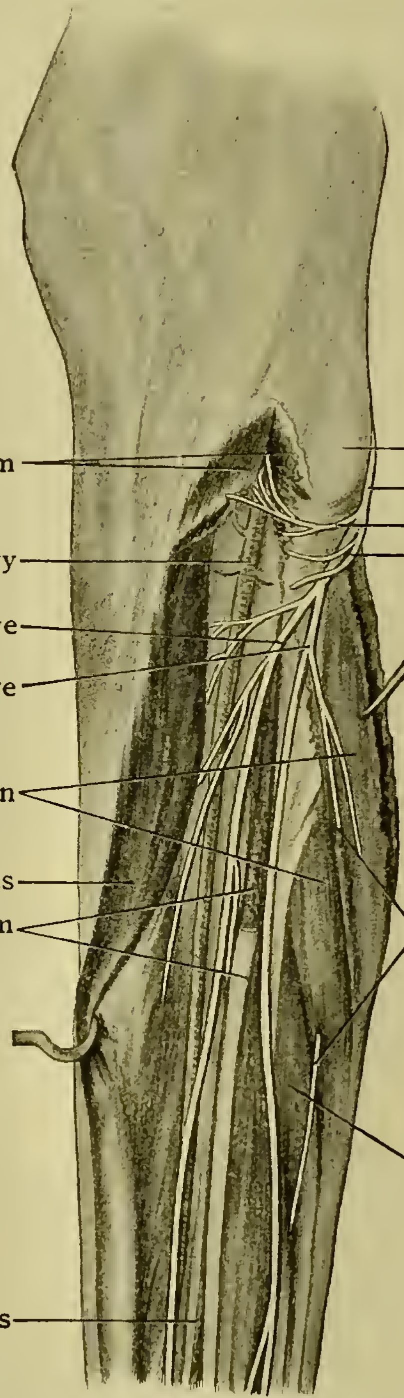

FIG. 124.—Dissection of antero-lateral surface of the left leg showing anterior tibial and musculo-cutaneous nerves.

base of the first metatarsal bone on its under and outer aspect and the adjacent portion of the internal cuneiform bone; **nerve-supply,** the musculo-cutaneous nerve (fourth and fifth lumbar and first sacral); **action,** to extend and evert the foot.

In denuding the surface of this muscle, the peroneal nerve will be encountered just below the head of the fibula and will be seen to pass

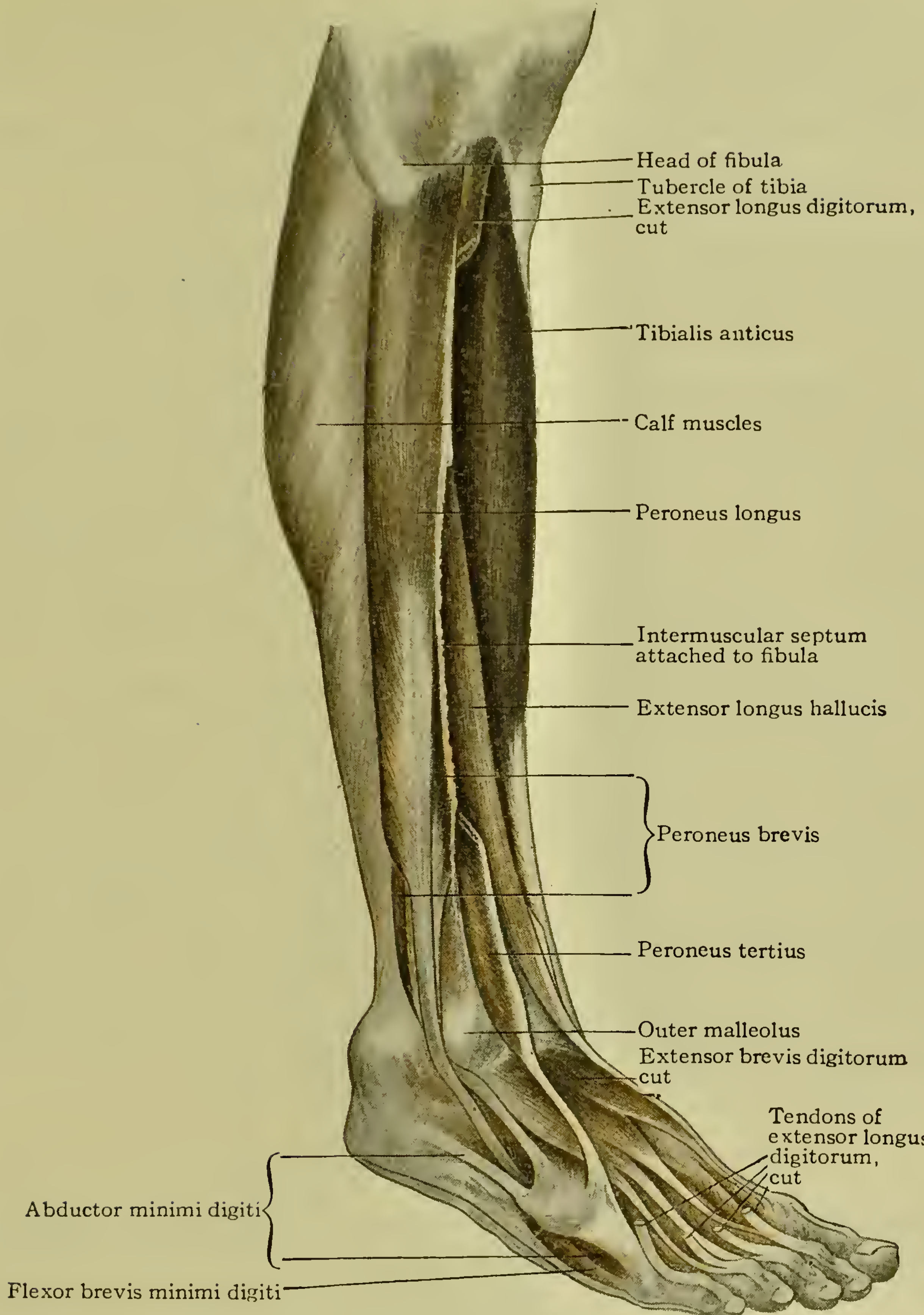

FIG. 125.—Superficial dissection of right leg, antero-lateral aspect, showing peroneal muscles.

beneath the upper part of the muscle. The tendon should be followed downward to the outer malleolus behind which it passes to the outer side of the foot. Its further course across the sole of the foot will be traced later (page 288).

THE PERONEUS BREVIS (Fig. 125).—**Origin,** the lower two thirds or three fourths of the outer surface of the fibular shaft; **insertion,** the

outer side of the base of the fifth metatarsal bone; **nerve-supply,** the musculo-cutaneous nerve (fourth and fifth lumbar and first sacral); **action,** to extend and evert the foot.

After having denuded this muscle its tendon should also be followed to the outer malleolus, behind which it passes in company with the tendon of the preceding muscle to the outer side of the foot.

Contraction of these muscles, as a result of infantile paralysis, for example, everts the foot, the patient walking on the inner edge of the sole; the condition is that variety of club-foot known as *talipes valgus*. *Tenotomy*, or division of the tendons, to correct this deformity is done most conveniently just above the outer malleolus.

The **external popliteal nerve** (n. peronæus communis), one of the terminal branches of the great sciatic (p. 184), leaves the popliteal space and passes around the outer side of the head of the fibula toward the anterior aspect of the leg, in which position it has already been encountered. Traced beneath the peroneus longus, which should be detached at its upper extremity and turned outward, it will be found to divide into the anterior tibial and the musculo-cutaneous nerves. The former has been considered.

The Musculo-Cutaneous Nerve (n. peronæus superficialis).—The musculo-cutaneous nerve should be traced downward through the interval between the peroneal muscles and the extensor longus digitorum or through the substance of the peroneus longus to the point where it becomes superficial by perforating the deep fascia (page 237). As stated previously, it divides into an internal and an external branch which go to the dorsum of the foot (page 253). The **branches** of the musculo-cutaneous nerve in the leg are *muscular branches* to the peroneus longus and brevis muscles which should be identified and traced. They arise near the beginning of the nerve (Fig. 124), one branch entering the peroneus longus above and another giving a lower branch to the longus and a branch or branches to the brevis.

THE DORSUM OF THE FOOT.

The **bones of the foot** are to be reviewed before beginning the dissection of the part, particular attention being paid the relation of the tarsal bones to each other and the areas of muscular attachment, especially those for the insertion of the muscles of the leg.

The Tarsus.—The tarsus, in the articulated foot (Fig. 126), presents on its upper aspect the **astragalus,** articulated below with the os calcis by two and sometimes by three articular surfaces, while on its upper and lateral surfaces are the articular facets for the tibia and fibula, and in front that for the scaphoid. The **os calcis** or **calcaneum** shows on its upper surface two (or three) articular facets for the astragalus, one of which, sometimes divided, is on the sustentaculum tali

(Fig. 127), while its anterior surface articulates with the cuboid. The **scaphoid** or **navicular** is noteworthy for its tuberosity on the inner surface, its three anterior articular facets for the cuneiform bones and its single posterior facet for the astragalus. Its outer surface may or may not

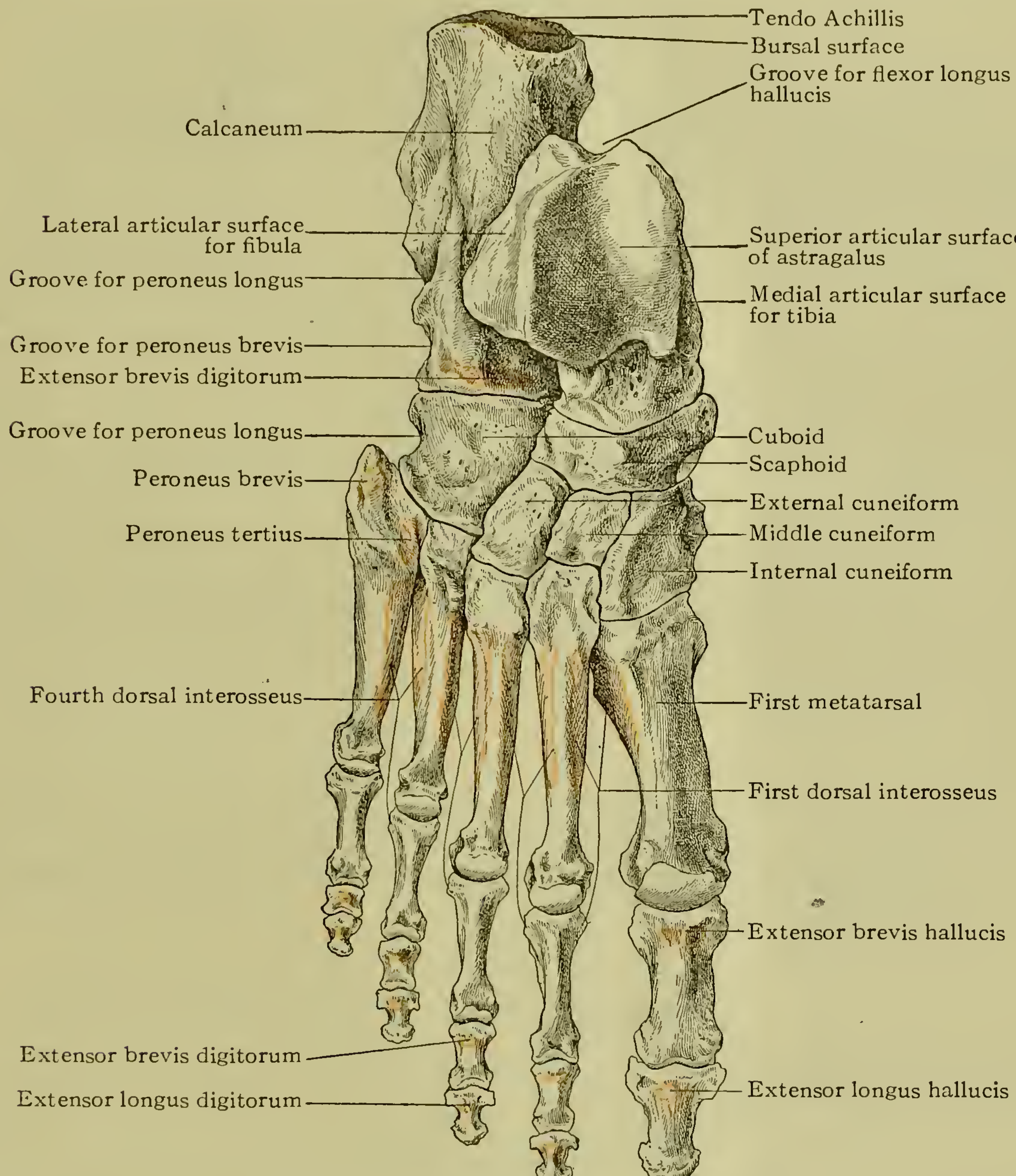

FIG. 126.—Bones of right foot, dorsal aspect.

articulate with the cuboid. The **cuboid** presents three articular and three non-articular surfaces. Of the former, the posterior surface articulates with the calcaneum, the anterior with the fourth and fifth metatarsi and the inner with the external cuneiform and sometimes with the navicular. Note the groove on its under surface for the peroneus longus tendon. The **three cuneiform bones** articulate behind with the

navicular and in front with the metatarsi, the *internal cuneiform* articulating with the first and second, the *middle* with the second, the *external* with the second, third and fourth metatarsal bones as well as with

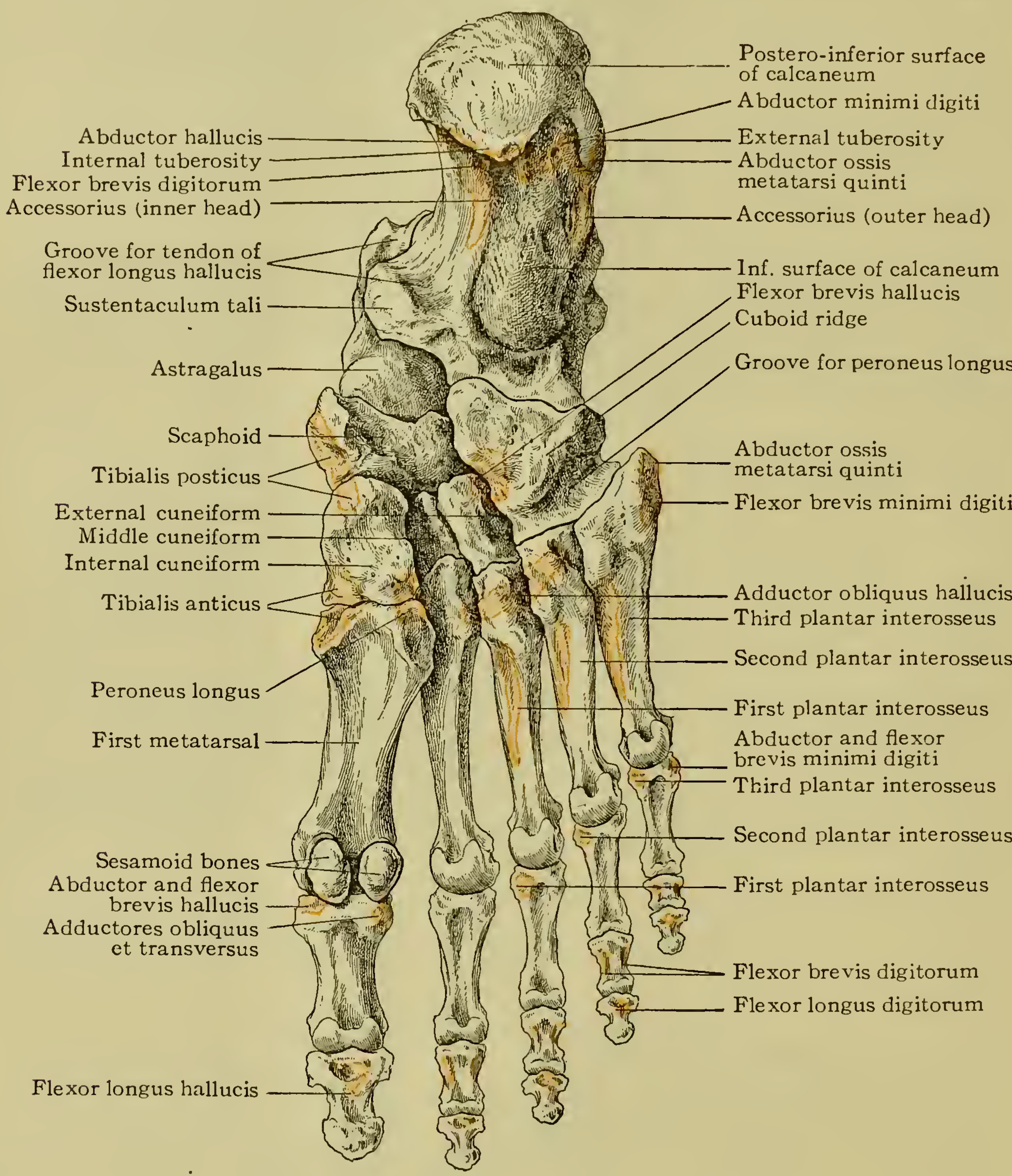

FIG. 127.—Bones of right foot, plantar aspect.

the cuboid. Note the small size of the middle cuneiform and the slight extent to which it is apparent on the under surface of the foot (Fig. 127).

The Metatarsus.—Note the distally tapering **shafts,** the proximal extremities or **bases** and their relations to the tarsus and to each other, and the distal extremities or **heads,** as well as the relative thickness

and length of the bones, the *first* being the most massive, the *second* the longest.

The Phalanges.—The phalanges, fourteen in number, two for the great toe and three for each of the others, are similar to those of the hand.

THE SURFACE ANATOMY.

The two **malleoli,** already noted, are conspicuous land-marks of the foot in the region of the ankle, the internal malleolus, the more prominent, being a half inch higher and farther forward than the external, and between these, anteriorly, the **tendons** of the tibial group of muscles may be recognized as tense bands when the dorsum of the foot is drawn up in flexion. Just below the bend of the ankle a bony prominence, the **head of the astragalus,** is encountered and is particularly obvious when the foot is extended and adducted. Passing downward from this point the foot widens and the individual **metatarsal bones** may easily be recognized. On the *inner side* of the foot about one inch below the malleolus the **sustentaculum tali** is obscurely felt, and about an inch in advance of this the **tuberosity of the scaphoid,** in front of which is the **internal cuneiform bone,** and still farther forward, the **base of the first metatarsal bone.** On the *outer side* of the foot, about an inch below and in front of the outer malleolus, is the **peroneal tubercle** of the os calcis—the outer surface of which is practically subcutaneous—marking the point of separation of the tendons of the peroneus longus and brevis, which may be recognized as tense ridges when the foot is strongly flexed and everted. About a half inch in front of this point the interval between the os calcis and the cuboid bone may sometimes be recognized, marking the position of what is known as the medio-tarsal joint. Farther forward the **tuberosity of the base of the fifth metatarsal bone** is easily palpable.

DISSECTION.

An incision from the middle of the bend of the ankle downward to the interval between the second and third toes, and a transverse incision across the proximal extremities of the toes, should be made. A median incision along the dorsal surface of each toe should be added (Fig. 97). The work of dissection will be facilitated if the tips of the toes are tacked or nailed to a board or block, for which purpose the leg may be flexed so as to bring the foot in a horizontal plane. The skin, which is of delicate texture, should be reflected toward either border of the foot.

The Superficial Fascia.—The superficial fascia of the dorsum of the foot is a loose cellular layer with comparatively little fat, and contains the superficial nerves and vessels. The looseness of this fascia explains the ready occurrence of swelling of the dorsum of the foot in

inflammatory conditions, as well as in either œdema or general dropsy. The **veins** consist of a plexus near the proximal part of the foot, receiving tributaries from the toes and being drained chiefly by the internal saphenous vein. They are usually so insignificant as to be negligible in dissection.

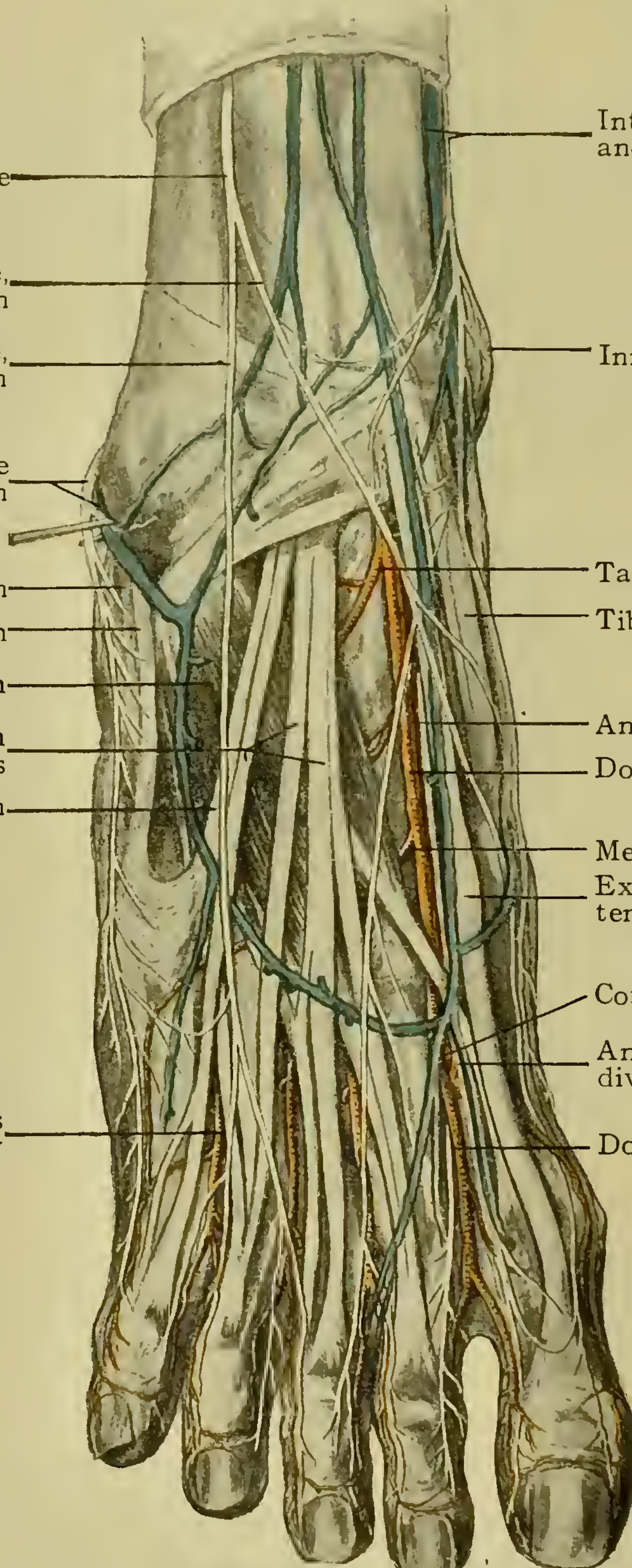

Fig. 128.—Dissection of dorsum of foot.

The Nerves.—The **internal saphenous nerve** (p. 210) should be followed along the inner side of the foot to its termination at the ball of the great toe, the terminal cutaneous branches which it gives off being noted (Fig. 128).

The **internal branch of the musculo=cutaneous** (Fig. 128) should be picked up at the bend of the ankle and followed toward the inner side of the foot, its *inner branch* to the inner side of the great toe, its *middle branch*, distributed along the first metatarsal space, and its *outer branch*, passing along the second metatarsal space to divide at the toe-cleft into two *dorsal digital* branches for the adjacent sides of the second and third toes, being followed out to their respective distributions. The **external branch of the musculo=cutaneous** should also be traced from the bend of the ankle to its division into *inner* and *outer branches*, each of which breaks up into *dorsal digital branches* for the clefts between the third and fourth, and the fourth and fifth toes respectively.

The **internal terminal branch of the anterior tibial nerve** (p. 245) becomes superficial near the anterior part of the foot on the outer side of the tendon of the extensor of the great toe, and should be traced from here to the cleft between the first and second toes, where it divides into *dorsal digital branches* for the supply of the adjacent sides of these digits. Traced backward, it will be found at a later stage of the dissection under the inner tendon of the extensor brevis digitorum, where it gives off the *first dorsal interosseous nerve* for the corresponding muscle and the first and second metacarpo-phalangeal joints. The **external terminal branch,** mentioned here as a matter of convenience, but to be dissected later, passes outward under the extensor brevis digitorum (Fig. 123) and gives rise to *two*, *three* or *four dorsal interosseous nerves* for the corresponding dorsal interosseous muscles and the adjacent joints.

The **external saphenous nerve** (p. 259) will be found on the outer side of the foot, which it reaches by coming from the posterior aspect of the leg behind the outer malleolus (Fig. 128), and may be traced forward to the outer side of the little toe, its branches of distribution to the skin as it goes being noted as well as its *external calcanean branches* (Fig. 130) to the outer side of the heel.

Thus it will be seen that the internal saphenous supplies the inner side of the foot as far as the ball of the great toe, that the musculo-cutaneous supplies the inner side of the great toe and the adjacent sides of the second and third, third and fourth, and fourth and fifth toes, while the anterior tibial supplies the adjacent sides of the first and second toes, and the external saphenous the outer side of the foot and the outer side of the little toe.

The Deep Fascia.—The deep fascia of the dorsum of the foot has no special significance except for the localized thickenings at the bend of the ankle constituting the **anterior annular ligament** (Fig. 121). The annular ligament consists of a *vertical portion* (p. 239) (lig. transversum cruris), passing from the front of the outer malleolus to the front of the inner malleolus, and a *horizontal portion* (ligamentum cruciatum), which passes from the lower part of the outer malleolus and from the adjacent

portion of the os calcis toward the inner side of the foot, dividing as it does so into an ascending limb and a descending limb (Fig. 121). The upper limb passes upward and inward to be attached to the inner malleolus, the lower limb downward and inward to become continuous with the inner border of the plantar fascia. Having demonstrated these thickened bands they may be incised in order to expose the underlying tendons. These tendons should now be successively traced to their respective terminations, first dissecting the **tibialis anticus tendon** (p. 240). In following the **extensor proprius hallucis tendon** to the big toe, note its expansion into aponeuroses as it crosses the metatarsal-phalangeal and the interphalangeal joints. In following the tendons of the **extensor longus digitorum** note that the inner three tendons are each joined on their outer side as they reach their respective toes by a tendon of the short extensor of the toes. Note further that each tendon receives a fibrous expansion from the interossei and lumbricales and then spreads into an aponeurosis which covers the dorsal surface of the first phalanx and which, at the first interphalangeal joint, divides into three parts, a *middle slip* for insertion into the base of the second phalanx, and two lateral slips, for insertion, after blending with each other, into the base of the last phalanx (Fig. 122). The **peroneus tertius tendon** may be followed to its insertion into the base of the fifth metatarsal bone.

The **region behind the outer malleolus** (Fig. 129) presents, after removal of the skin and superficial fascia, the **external lateral ligament** (retinacula mm. peronæorum), consisting of an upper band, extending from the malleolus downward and backward to the calcaneum, and a lower fasciculus, passing from the back part of the outer surface of the calcaneum to the fore part of the same surface. Incising this ligament, the tendons of the **peroneus longus** and **peroneus brevis** are disclosed lying in one groove and having a synovial sheath in common. The longus tendon should be traced forward and somewhat downward to the beginning of the fibrous canal it traverses on the sole of the foot; the brevis, forward above the peroneal tubercle to the base of the fifth metatarsus.

The Dorsalis Pedis Artery.—The dorsal artery of the foot, the continuation of the anterior tibial, should be followed from the bend of the ankle in its course to the back part of the first intermetatarsal space—its **surface line** being a line connecting these two points—the dissector having regard for the branches which are given off from the vessel. It **terminates** by dividing into the *dorsalis hallucis* and the *communicating arteries.*

The **dorsalis hallucis,** giving off a branch to the inner side of the great toe, continues to the interval between the great and second toes, where it divides into two *dorsal digitals* for the adjacent sides of these toes.

The **communicating branch,** passing through the back part of the first intermetatarsal space, unites with the external plantar artery to form the plantar arch. Before reaching the external plantar artery, it gives origin to the *princeps hallucis,* which will be found in the dissection of the sole as it passes forward along the first interosseous space to bifurcate at the toe-cleft into the two *plantar digitals* for the adjacent sides of the first and second toes.

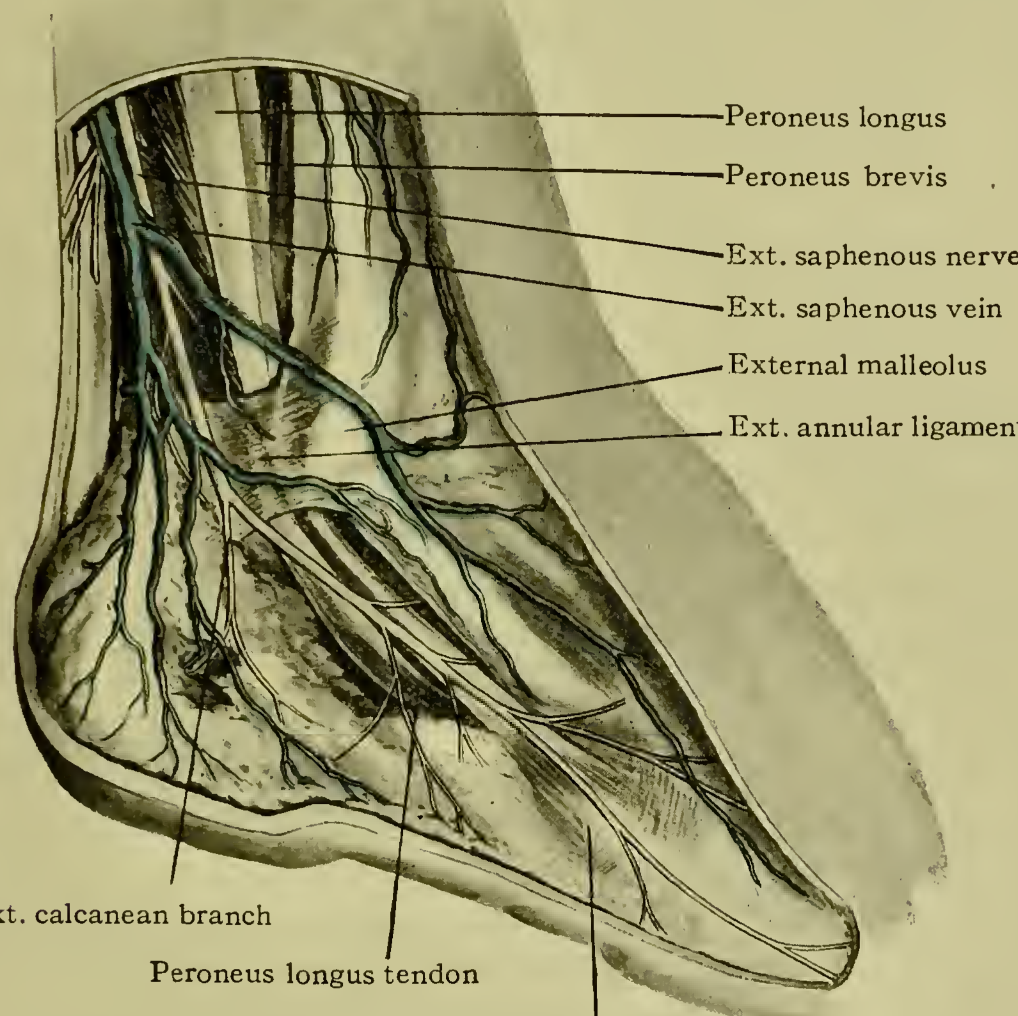

Fig. 129.—Dissection of lateral aspect of right ankle.

The **branches** of the dorsalis pedis, in addition to the terminal branches, are the *internal tarsal,* the *external tarsal,* the *metatarsal,* and some *cutaneous* and *muscular* branches.

The **internal tarsal branches** arise opposite the inner malleolus (Fig. 123), in the region of which they ramify, and may be exposed by displacing the tibialis anticus tendon. They are small vessels.

The **external tarsal** or **tarsal branch** (Fig. 123), arising near the head of the astragalus and passing downward and outward toward the outer side of the foot under the extensor brevis digitorum, gives off *cutaneous, muscular* and *articular branches* and anastomoses with the external

malleolar, anterior peroneal, external plantar and metatarsal arteries. Its dissection must be deferred, at least in part, until after the removal of the extensor brevis digitorum.

The **metatarsal branch,** given off near the termination of the artery, passes downward and outward, over the bases of the metatarsi, except the first, and beneath the tendons, and gives off three *dorsal interosseous branches* to the second, third and fourth intermetatarsal spaces, which communicate by the *anterior* and *posterior perforating branches* respectively with the plantar arch and its digital branches through the front and back parts of the spaces.

The Relations of the Dorsalis Pedis.—The tendon of the extensor proprius hallucis is upon the inner side of the vessel and the latter is crossed from without inward near its termination by the innermost tendon of the extensor brevis. The inner terminal branch of the anterior tibial nerve is in immediate relation with the outer side of the vessel, separating it from the innermost tendon of the long extensor of the toes and from that of the short extensor. It rests upon the anterior annular ligament at the ankle, and then in turn upon the astragalus, the navicular, the internal and middle cuneiform bones and the several dorsal ligaments connecting these bones. It is covered at its commencement by the annular ligament and elsewhere by the skin and fasciæ.

The dorsalis pedis may be abnormally *small*, the branches of the external plantar which reach the dorsum of the foot being compensatorily large; it may arise as a branch of the peroneal artery or of the external plantar.

The Extensor Brevis Digitorum (Fig. 125).—**Origin,** the anterior portion of the upper and outer surfaces of the os calcis; **insertion,** by four tendons into the four greater toes, the innermost tendon being inserted independently into the great toe, but the remaining three tendons joining the outer side of the corresponding tendon of the long extensor; **nerve-supply,** the anterior tibial nerve (fourth and fifth lumbar and first sacral); **action,** extension of the four greater toes.

This muscle having been dissected, it should be divided near its origin—the overlying tendons being either pulled aside or cut—and reflected carefully to avoid injury to the nerves and vessels beneath it. The tarsal and metatarsal branches of the dorsalis pedis (p. 255) and the external branch of the anterior tibial nerve (p. 245) may then be worked out.

Paralysis of the external popliteal or peroneal nerve may be caused by *traumatism,* such as a blow on the outer side of the leg below the head of the fibula or compression of the nerve by the biceps tendon in those whose occupations require much kneeling, by *lead-poisoning*, or in the course of *tabes dorsalis*. The anterior tibial and the peroneal groups of muscles and the short extensor of the toes being paralyzed, there will be loss of dorsal flexion of the foot, the latter dropping and the toes dragging on the ground in walking; defective inversion and adduction (tibialis anticus), loss of eversion (peronei longus

et brevis), and impairment of the transverse arch of the foot (peroneus longus). Extension of the toes is impaired but not lost, since the interossei and lumbricales, innervated by the plantar nerves, extend the second and third phalanges. Sensation is impaired on the antero-lateral and posterior surfaces of the leg (communicans peronei) and the top and outer side of the foot (external saphenous, musculo-cutaneous and anterior tibial nerves), except on the distal parts of the toes.

The anterior surface of the leg and the top of the foot should now be protected by damp cloths and the limb should be turned over to permit of the dissection of the posterior structures of the leg and of the sole of the foot.

THE POSTERIOR ASPECT OF THE LEG.

THE SURFACE ANATOMY.

The prominent swell of the upper part of this region, due to the underlying **calf=muscles,** gives place in the lower third of the leg to a less rotund contour, the two chief muscles of the calf narrowing to the large **tendo Achillis,** which is recognizable as a prominent median ridge in the lower fourth of the leg and which may be followed downward to the heel. Deep pressure along the inner side of this tendon, especially near the lower limit of the leg, may detect the pulsations of the posterior tibial artery in the living subject. A more or less conspicuous blue line along the median aspect of the posterior surface of the calf, if present, indicates the course of the short or external saphenous vein.

DISSECTION.

A median longitudinal incision should be made extending down to the convexity of the heel, to which should be added a curved incision corresponding to the inner and outer and posterior borders of the heel. The skin-flaps thus outlined should be reflected toward each side of the leg, exposing the superficial fascia.

The Superficial Fascia.—This tissue, fairly well supplied with fat, presents nothing peculiar and is of interest only as being the seat of the superficial nerves and vessels, the only important members of these classes being the short or external saphenous vein, and the external saphenous nerve with the two trunks that unite to form it.

The External Saphenous Vein (v. saphena parva). — This vein, beginning on the outer side of the dorsum of the foot (Fig. 130) and passing upward and backward behind the outer malleolus, takes its course up the middle of the back of the leg, receiving numerous tributaries as it goes, to the popliteal space, in which situation it usually pierces the deep or popliteal fascia to terminate in the popliteal vein. It may, however, pierce the deep fascia in the upper third of the leg. Since the terminal portion of the vein has been dissected it may be fol-

lowed downward to the level of the outer malleolus, in doing which the dissector must be on guard for the external saphenous nerve, which accompanies the vein very closely, lying on a deeper plane.

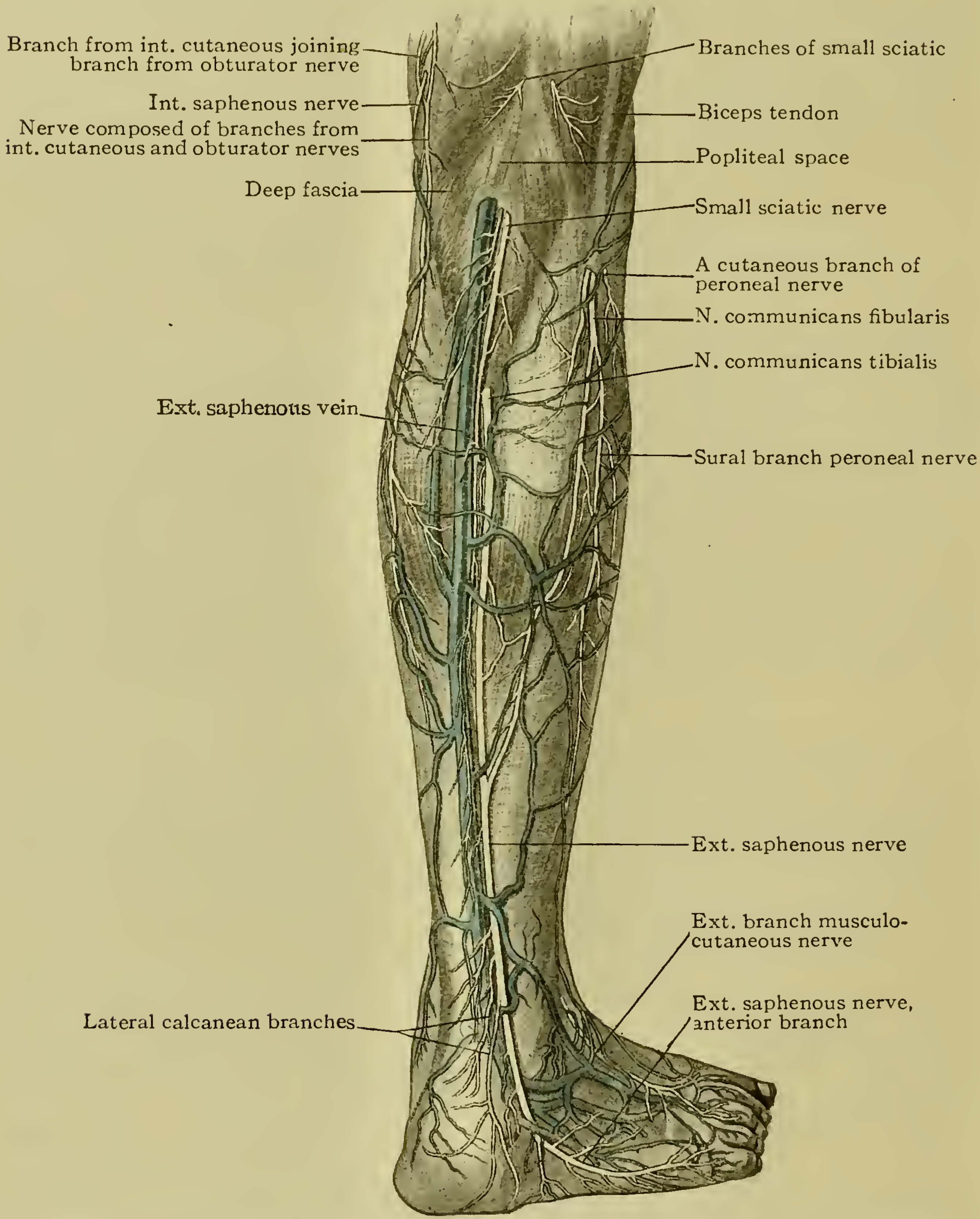

Fig. 130.—Superficial nerves and veins of posterior aspect of leg and outer aspect of foot.

The **femoro=popliteal vein** passes from the termination of the short saphenous to empty into the deep femoral vein (Fig. 88). The short saphenous vein is provided with from three to nine valves.

Both this vein and the internal saphenous and their tributaries are notably prone to become *varicose*. The close proximity of the short saphenous nerve and of the internal saphenous nerve to the short saphenous and internal saphenous veins respectively is thought to account for the neuralgic pains often associated with varicose veins of the leg.

The External or Short Saphenous Nerve (n. suralis).—The external saphenous nerve may be formed anywhere from the lower limit of the popliteal space to the middle of the leg or even lower by the union of the communicans peronei or fibularis of the external popliteal nerve and the communicans poplitei or tibialis from the internal popliteal nerve (Fig. 130). As these two important cutaneous nerves have been identified in the dissection of the popliteal space, it only remains to follow them downward to their point of junction with each other. In doing so, too great traction upon the trunks should be avoided lest they be torn. The short saphenous nerve gives off cutaneous filaments to the skin of the back of the leg as it passes along and is finally distributed to the skin of the outer side of the foot (external calcanean branches) and the outer side of the little toe (p. 253).

The terminal portion of the **small sciatic nerve** (p. 176) may also be found in the superficial fascia of the upper half of the posterior aspect of the leg. Having isolated these structures the superficial fascia may be removed to expose the deep fascia.

THE DEEP FASCIA (fascia cruris).—This presents no special features other than those previously noted (p. 238), the fascia merely forming an investment for the muscles of the region and giving off some deep **septa** which will be noted below. The deep fascia may now be incised in the median line from the apex of the popliteal space to the heel; it should then be reflected toward either side. This will expose the gastrocnemius muscle and the tendo Achillis. In reflecting it from the lower third or fourth of the leg, that is, below the muscular portion of the gastrocnemius, the dissector should avoid taking up with it a layer of deep fascia which underlies it, and which is the lower part of the **deep transverse intermuscular septum** (p. 240). The thickening of the deep fascia between the inner malleolus and the convexity of the heel, **the internal annular ligament** (p. 240), should also be left intact. Along the inner border of the tendo Achillis the dissector will encounter the long slender tendon of the plantaris.

THE GASTROCNEMIUS MUSCLE (Fig. 131).—**Origin,** by two heads from the upper parts of the inner and outer condyles of the femur and the surface of bone immediately above them; **insertion,** by the tendo Achillis into the lower part of the posterior surface of the os calcis; **nerve-supply,** the internal popliteal nerve (first and second sacral); **action,** extension of the foot.

Having carefully denuded this muscle and noted its central tendinous raphe, the aponeuroses into which the heads of the muscle expand on

the superficial surface and the aponeurosis on the deep aspect of the lower part of the muscle which narrows below into the tendo Achillis, it should be gently raised by insinuating the fingers first under one

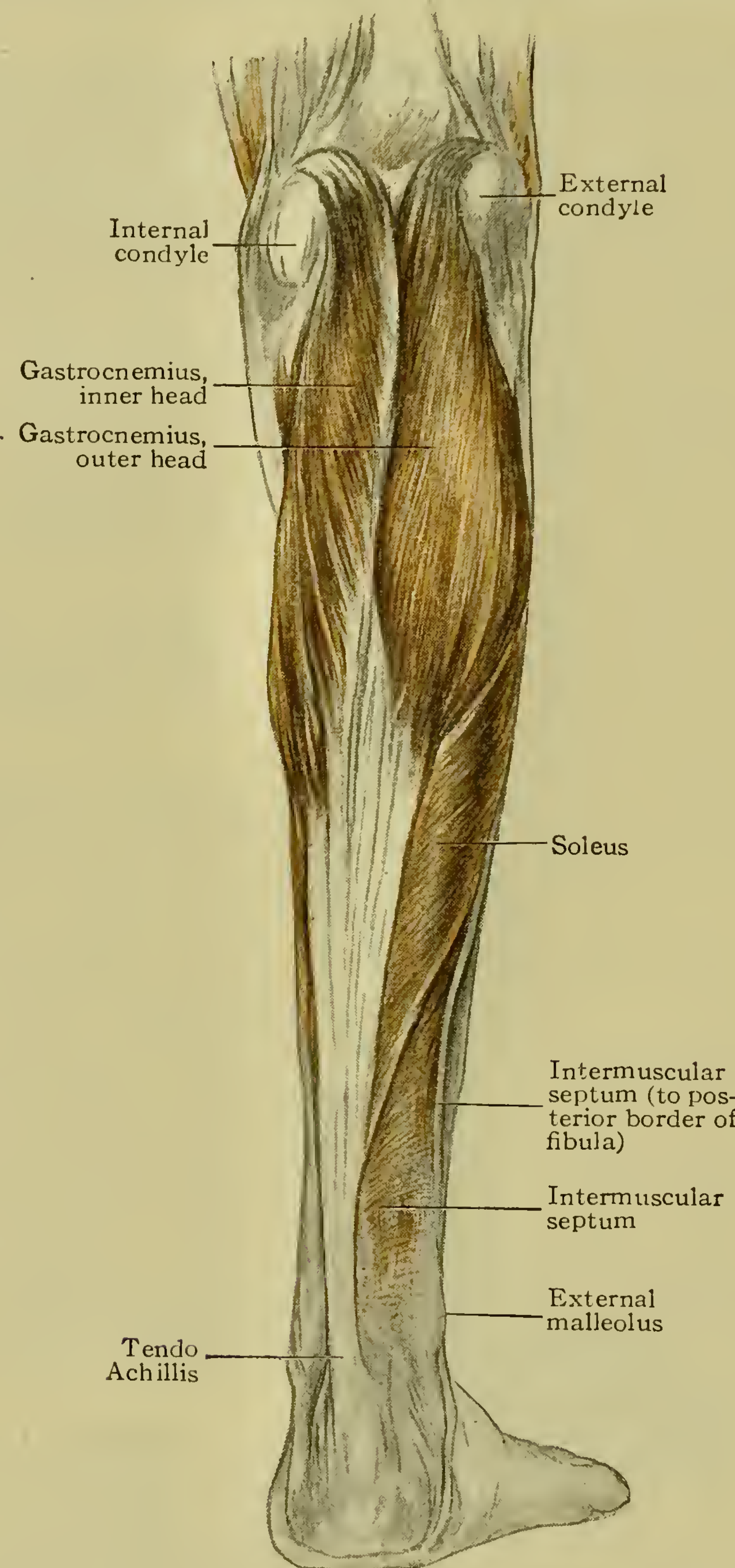

FIG. 131.—Superficial dissection of posterior surface of right leg, showing muscles undisturbed.

edge and then under the other, and its loose connection with the underlying soleus muscle noted. The tendon of the plantaris will also be found in this interval between the gastrocnemius and the soleus.

The **bursæ of the gastrocnemius,** one between the inner head and the inner condyle and one between the outer head and the outer condyle, may be made evident by pulling each tendon of origin away from the corresponding condyle (Fig. 134).

In a supracondylar fracture of the femur the lower fragment is made to project backward by the action of the gastrocnemius, to correct which the leg must be flexed upon the thigh, as by putting the limb upon a double-inclined plane splint.

The Plantaris (Fig. 132).—**Origin,** the posterior ligament of the knee-joint and the outer supracondylar ridge of the femur; **insertion,** into the os calcis and partly into the tendo Achillis; **nerve=supply,** the internal popliteal nerve (fifth lumbar and first sacral); **action,** extension of the foot.

This muscle having been dissected in the dissection of the popliteal space, it only remains to follow its tendon to its termination. The plantaris of man is a rudimentary structure, representing a more important muscle in some animals, which in them is a tensor of the plantar fascia, being analogous, therefore, to the palmaris longus of the upper extremity.

The Soleus (Fig. 132).—**Origin,** the upper third of the posterior surface of the shaft of the fibula and the posterior surface of its head, the oblique line of the tibia and the middle third of the inner border of the tibia; **insertion,** in connection with the gastrocnemius by means of the tendo Achillis into the posterior surface of the os calcis; **nerve=supply,** the internal popliteal nerve (the first and second sacral); **action,** extension of the foot.

To expose this muscle the gastrocnemius may be held to one side or may be divided near its origin and reflected downward. The loose cellular tissue should be removed from the superficial surface of the muscle and the aponeurotic character of this surface should be noted. Insinuating the fingers under the lower portions of the two borders of the muscle and under the upper part of its tendon, it should be elevated so as to demonstrate the extent of its attachment to the posterior surface of the fibula and to the middle third of the inner border of the tibia. The remaining part of the tendo Achillis should now be elevated and followed downward to its termination and the presence of the **retro=calcanean bursa** between the lower part of the tendon and the upper part of the posterior surface of the os calcis should be noted. A **bursa** is sometimes found in relation with the posterior surface of the tendon also.

Permanent contraction or shortening of the calf muscles is responsible for the form of club-foot known as *talipes equinus*, in which the patient walks on the ball of the foot. Tenotomy or cutting of the tendon for this condition is usually done a short distance above the termination of the tendon, the proximity of the posterior tibial artery to the tendon, the latter lying upon the inner side and somewhat deeper, being taken into account. In fractures of the os calcis these muscles draw up the upper fragment and necessitate extension of the foot to overcome the separation.

The tibial origin of the soleus muscle should be severed, the inner border of the muscle below its attachment to the tibia being elevated with the fingers or blunt dissector so as to divide the muscle without

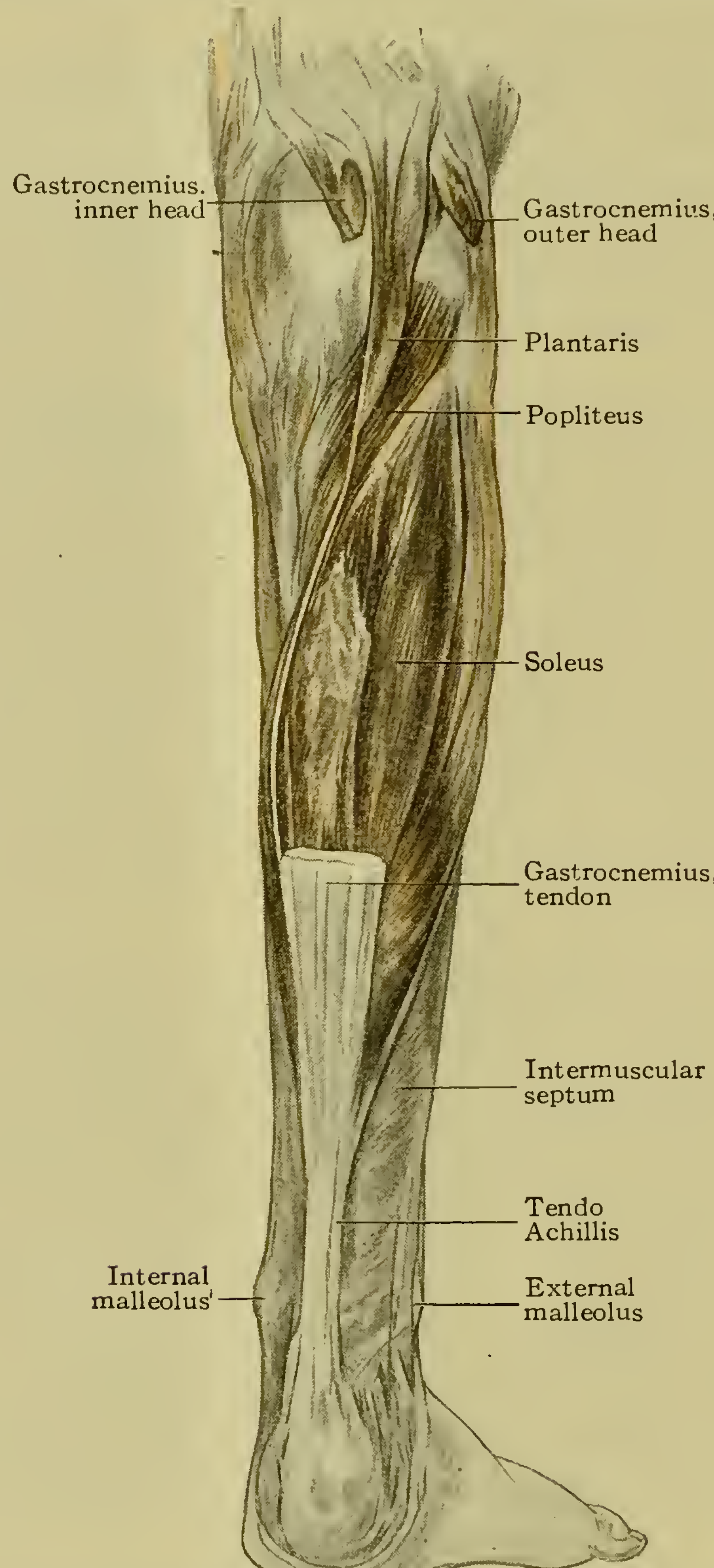

FIG. 132.—Muscles of posterior surface of right leg; gastrocnemius has been removed, exposing plantaris and soleus.

injuring the underlying tissue. The division may be carried also along the attachment of the muscle to the oblique line of the tibia, when the muscle may be turned toward the outer side of the leg.

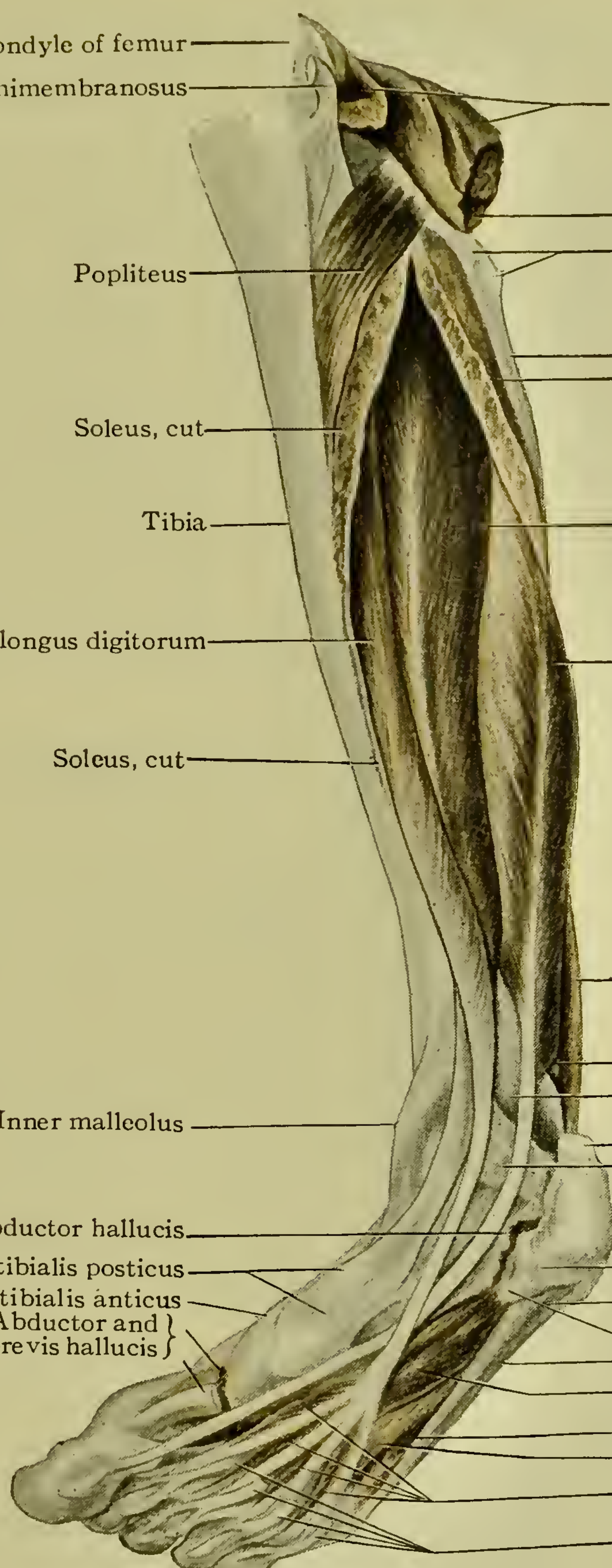

FIG. 133.—Deeper dissection of right leg, showing flexors passing into foot.

The **deep transverse fascia** or intermuscular septum is now exposed. It is seen to be attached to the inner border of the tibia and to the postero-external border of the fibula, and through it may be obscurely seen the underlying deep muscles of the leg. Following this deep layer of the deep fascia downward it will be noted that it thickens in the

interval between the inner malleolus and the convexity of the heel to form a strong band, the **internal annular ligament,** which binds down the tendons of the deep muscles on their way to the sole of the foot. Above, the transverse fascia is continued over the popliteus muscle. This fascia should be removed, making for the purpose a median longitudinal incision and reflecting the fascia toward either side, exposing the deep muscles as well as the blood-vessels and nerves. The cellular tissue should be removed from these structures without disturbing the relations of any of them, thus cleaning the surfaces of the muscles so far as can be done without displacement. The most superficial muscle is one upon the fibular side of the leg, the flexor longus hallucis. Beginning at the bifurcation of the popliteal artery the posterior tibial artery may be traced downward and denuded so far as this can be effected without disturbance of muscular relations. The large branch of this vessel, the peroneal artery, arising at the upper part of the leg, will also be encountered and will be seen to enter apparently the substance of the flexor longus hallucis.

The Flexor Longus Hallucis (Fig. 133).—**Origin,** the lower two-thirds or three-fourths of the posterior surface of the shaft of the fibula, the intermuscular septa and the interosseous membrane; **insertion,** the last phalanx of the great toe; **nerve=supply,** the posterior tibial nerve (fourth and fifth lumbar and first sacral); **action,** flexion of the great toe.

Complete the dissection of this muscle by separating it from its neighbors by blunt dissection, and following its tendon to the interval between the inner malleolus and the heel, noting that the tendon occupies a groove in the posterior surface of the lower extremity of the tibia in passing toward the inner side of the leg and then traverses a groove in the posterior surface of the astragalus. Its further course will be noted later (p. 283). This muscle encloses a considerable portion of the peroneal artery and should be separated sufficiently to expose that vessel and to permit of its dissection.

The Flexor Longus Digitorum (Fig. 133).—**Origin,** the inner half of the posterior surface of the shaft of the tibia below the oblique line extending to within a few inches of the lower extremity of the bone; **insertion,** into the distal phalanges of the four lesser toes, after the manner of the flexor profundus digitorum of the upper extremity; **nerve=supply,** the posterior tibial nerve (fifth lumbar and first sacral); **action,** flexion of the phalanges of the four lesser toes.

Denuding this muscle and following its tendon, the latter will be seen to pass also through the interval between the inner malleolus and the heel.

The Tibialis Posticus (Fig. 134).—**Origin,** the outer half of the posterior surface of the shaft of the tibia below the oblique line, the upper two thirds of the internal surface of the shaft of the fibula, and

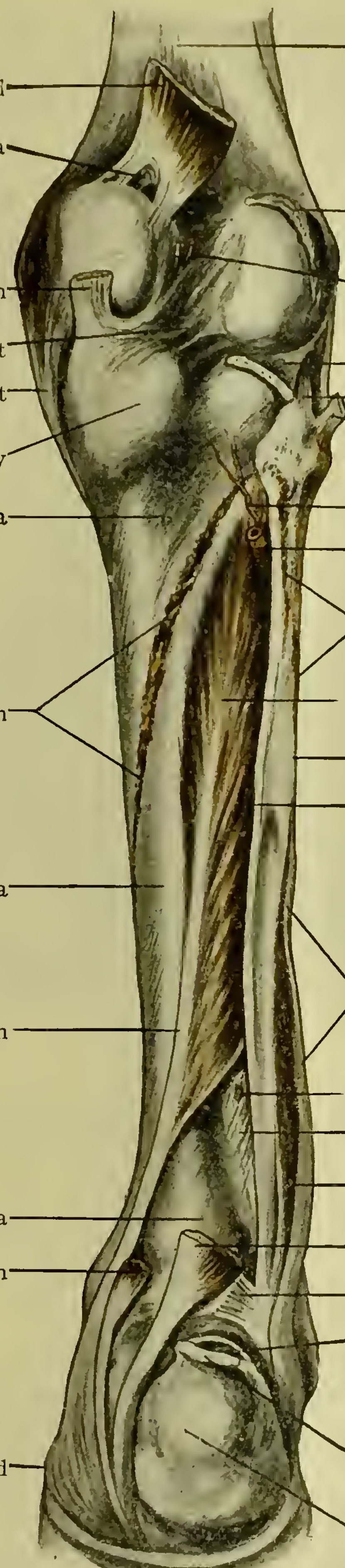

FIG. 134.—Deep dissection of posterior aspect of the leg with special reference to the tibialis posticus.

the interosseous membrane (Fig. 137); **insertion,** the tuberosity of the scaphoid and the internal cuneiform bone, and by extensions into the sustentaculum tali, the middle and external cuneiform bones, the

cuboid and the second, third and fourth metatarsal bones (Fig. 154); **nerve=supply,** the posterior tibial nerve (fourth and fifth lumbar and first sacral); **action,** inversion of the sole and extension of the foot.

In denuding this muscle the dissector will note an interval at its upper part between the tibial and fibular origins between which the anterior tibial artery passes toward the front of the leg. The tendon of the muscle should be followed to the space between the inner malleolus and the heel as in the case of the preceding tendons. It

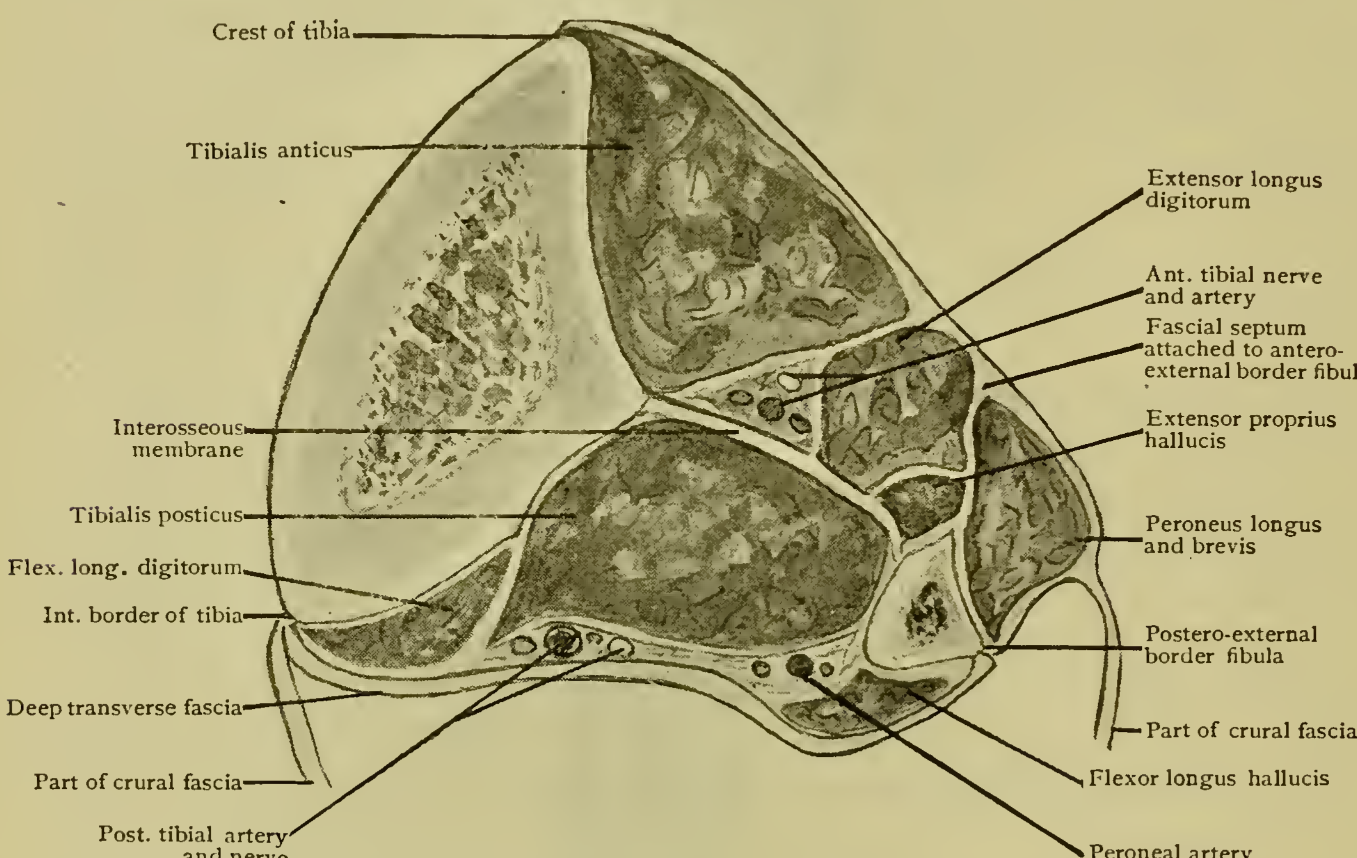

FIG. 135.—Diagram of cross-section through right tibia and fibula at the middle of the leg to show the relative positions of the bones and the relations of the fascial septa.

is placed nearer the inner malleolus than any of the other structures traversing this space. Its further course will be traced in the dissection of the foot.

THE POSTERIOR TIBIAL ARTERY (Fig. 137).—This vessel, **originating** at the lower border of the popliteus as one of the terminal branches of the popliteal artery, is accompanied in its course down the leg by the posterior tibial nerve, and **terminates** behind the inner malleolus by dividing into the internal and external plantar arteries. Its course is indicated by a **surface line** drawn from a point one inch below the centre of the popliteal space to a point midway between the inner malleolus and the convexity of the heel.

The **branches of the posterior tibial artery,** which should be recognized in denuding the vessel, are the *peroneal*, a large trunk, sometimes larger than the posterior tibial, which passes down the fibu-

lar side of the leg; the *nutrient to the tibia*, given off in the upper third of the vessel's course and noteworthy as the largest nutrient artery of bone in the body; various *muscular* and *cutaneous branches;*

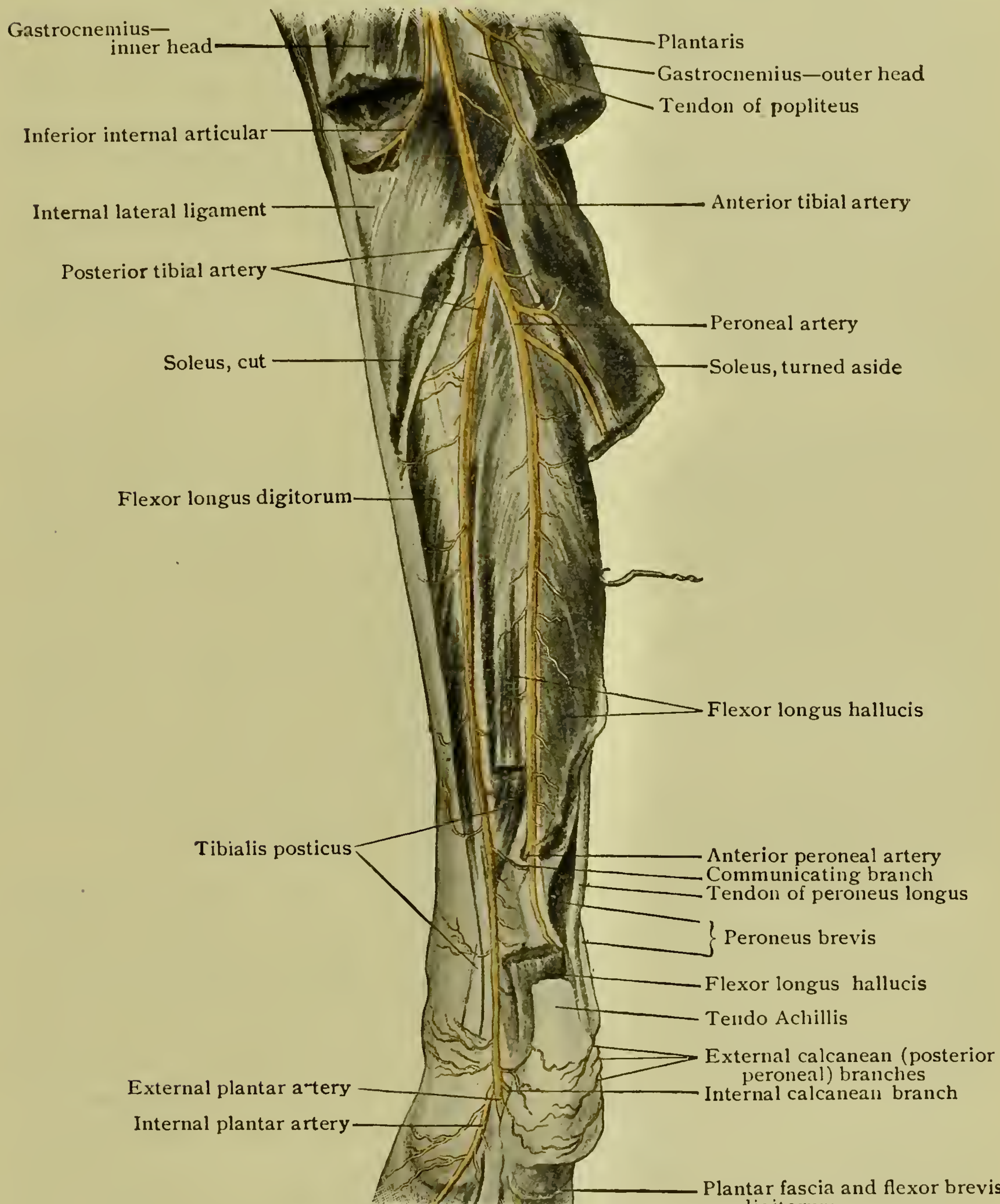

FIG. 136.—Arteries of posterior surface of right leg.

the *communicating branch*, arising near the lower extremity of the tibia and uniting with a communicating branch from the peroneal; the *internal malleolar*, arising near the termination of the vessel and

being distributed about the inner ankle; the *internal calcanean* (Fig. 136), supplying the superficial structures about the inner part of the heel; and the *terminal branches* mentioned above.

The Relations of the Posterior Tibial Artery.—Having completed the dissection of the artery and its branches, the relations of the vessel should be noted. The posterior tibial nerve lying upon the inner side of the vessel above, soon gains a position upon the outer or fibular side, which it maintains. The artery rests, from above downward, upon the tibialis posticus muscle, the flexor longus digitorum, the lower part of the tibia and the internal lateral ligament of the ankle-joint. It is accompanied by two veins which are closely associated with it. It is covered by the deep transverse fascia and, in the upper half or two thirds of the leg, by the gastrocnemius and soleus, while in the lower third it is covered simply by the skin and fasciæ, except at its termination, where it is beneath the internal annular ligament.

Ligation of this vessel, in the upper part of its course, as will be evident from what has been said of its relations to the calf muscles, is a somewhat difficult procedure. The artery may be reached by a median incision through the skin and underlying fascial layers and through the gastrocnemius and soleus; or by an incision behind the inner border of the tibia through the skin and superficial and deep fasciæ, after which the attachment of the soleus to the middle third of the inner border of the tibia is to be divided, thus exposing the deep transverse fascia, which must in turn be incised in order to expose the vessel. The precaution is to be observed not to mistake the superficial aponeurosis of the soleus for the deep transverse fascia, an error which might result in a fruitless search between the soleus and gastrocnemius for the vessel. Ligation of the posterior tibial artery in the lower third of the leg is a much simpler procedure, since it is not covered here by thick muscular masses, but only by the skin and superficial and deep fascia. An incision along the inner border of the tendo Achillis may be made through the skin and superficial fascia down to the deep fascia, which may in turn be incised to expose the vessel. It will be found here between the tendons of the tibialis posticus and the flexor longus digitorum.

The Posterior Tibial Nerve (n. tibialis).—This nerve, a continuation of the internal popliteal nerve, has been at least partially dissected in dissecting the posterior tibial artery. Lying upon the inner side of that vessel above and on its outer or fibular side throughout the remaining part of its course (Fig. 137), it passes to the interval between the inner malleolus and the heel and divides here into its two *terminal branches*, the internal and external plantar nerves. Its **branches** in its course down the leg are *muscular branches* to the flexor longus hallucis, the tibialis posticus and the flexor longus digitorum and near the inner malleolus, the *internal calcanean* and the *articular* to the ankle-joint.

The **muscular branches** enter their muscles in the upper part of the leg. The branch to the tibialis posticus gives off a branch which accompanies the peroneal artery, distributing branches to it and to the fibula.

The **internal calcanean branch** perforates the internal annular ligament and sends cutaneous filaments to the heel and back part of the

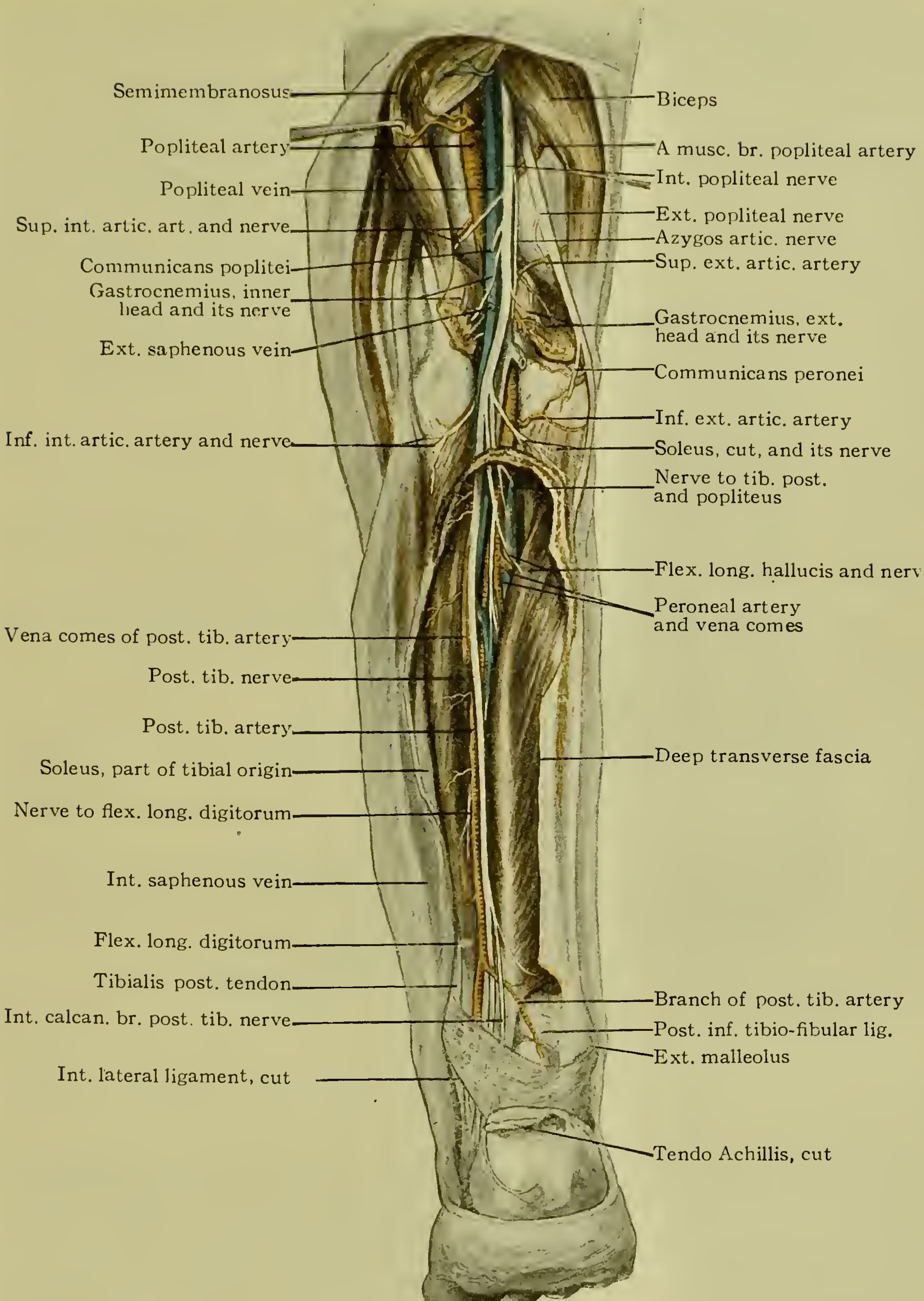

FIG. 137.—Deep dissection of the posterior aspect of the leg, showing vessels and nerves.

sole (Fig. 138), the *internal calcanean* and *calcaneo-plantar*. This nerve will be dissected in connection with the structures behind the inner malleolus, as will also the **articular branch.**

The Peroneal Artery.—This vessel, mentioned above as the largest branch of the posterior tibial, arises from the latter about an inch and a half from its origin. As its name indicates, it passes down the peroneal or fibular side of the leg, being embraced throughout the greater part of its extent by the flexor longus hallucis muscle, which latter has already been separated to expose the artery. Its **branches** are *muscular branches*, a *nutrient branch to the fibula*, the *anterior peroneal*, a *communicating branch* in the lower part of the leg anastomosing with the communicating branch of the posterior tibial, a *posterior peroneal* and an *external calcanean branch* from the termination of the artery passing respectively to the posterior and outer aspects of the heel. As noted above, this vessel is sometimes as large as, or larger than, the posterior tibial artery itself.

The **nutrient artery** should be followed to its entrance into the nutrient foramen of the fibula a little above the middle of the bone.

The **anterior peroneal** when traced is seen to perforate the interosseous membrane a short distance above the ankle to reach the front of the leg, in which region it has been dissected (p. 245).

The **posterior peroneal** and the **external calcanean** (Fig. 136) are the terminal branches of the vessel; they should be worked out as completely as possible.

The Space Between the Inner Malleolus and the Heel.—This region merits special consideration because of the important structures which traverse it. These may be exposed by continuing the dissection of the skin and superficial and deep fascia from the lower extremity of the leg. The deep fascia thickens here to constitute a strong and broad band, the **internal annular ligament** (p. 264), connecting the extremity of the malleolus with the posterior part of the calcaneum, and binds down the tendons and nerves and vessels.

Making an incision immediately behind the malleolus, the tendon of the tibialis posticus will be exposed (Fig. 138).

A little behind this will be found the tendon of the flexor longus digitorum. Farther back is the posterior tibial artery with an accompanying vein immediately in front of it and one immediately behind. Following the posterior tibial artery it will be seen to divide into its two terminal branches. A short distance behind the vessels lies the posterior tibial nerve. This should be cleaned and the origin of the rather large cutaneous **internal calcanean** branch noted (Fig. 138) as well as the division of the trunk of the nerve into its two terminal branches, the internal and external plantar nerves. An articular branch to the ankle-joint will also be encountered here. Some little distance behind this nerve the tendon of the flexor longus hallucis will be found. This tendon should be dissected and followed a short distance upward that its relations to the groove on the posterior aspect of the astragalus

may be noted, as also its relation to the groove on the posterior surface of the lower extremity of the tibia (Fig. 152). Following the tendon forward its relation to the sustentaculum tali will be noted (Fig. 152).

The Tibia.—The **upper epiphysis** of the tibia, which frequently but not invariably includes the tubercle, is rarely *fractured* except in association with a fracture of the upper end of the shaft as the result of great violence. *Separation* of this epiphysis is also rare on account of certain anatomical features, such as the toughness of the periosteum, the denseness and strength of the enveloping aponeuroses of the vasti

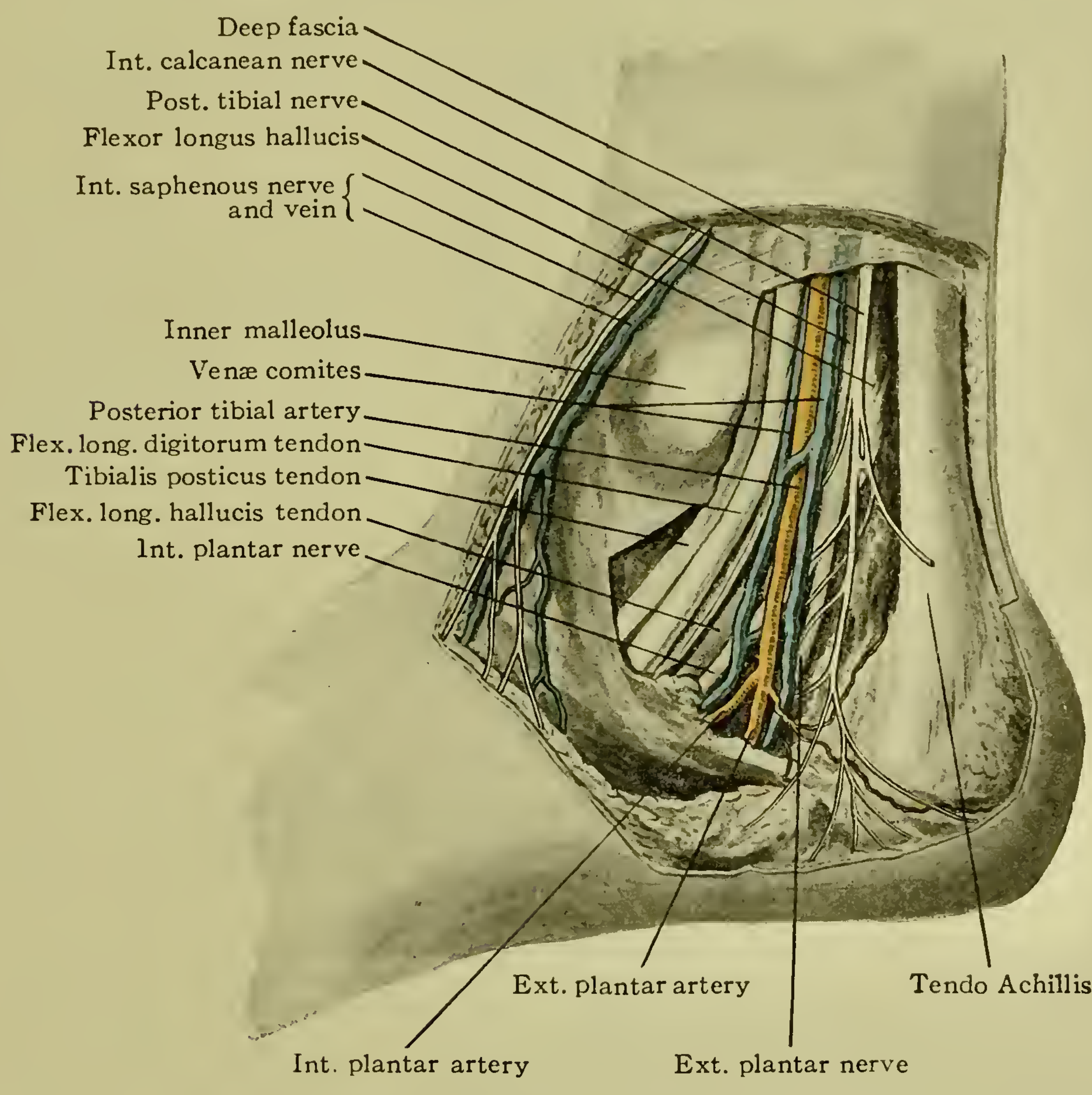

FIG. 138.—Dissection of medial aspect of ankle.

muscles and the size and shape of the epiphysis and its relation to the diaphysis. The injury may occur prior to the twentieth year. Since the growth in length is chiefly from the upper epiphysis, the lesion may cause an arrest of growth.

Fractures of the **shaft** of the bone, when from indirect violence, occur most frequently at the junction of the lower and middle thirds, where the bone is thinnest and weakest. The line of fracture is usually oblique from above downward and forward and slightly inward. Owing to the subcutaneous relations of the crest and inner surface, fracture is often compound. Other parts of the shaft are liable to fracture from direct violence, the line of fracture usually being transverse. Displacement in such cases is relatively slight, owing to the protection afforded by the fibula as well as to the transverse line of fracture.

Fracture of the **lower extremity** of the bone is rare except that of the inner malleolus in association with Pott's fracture of the fibula. *Separation of the lower* epiphysis is another rare injury, but considerably less so than that of the upper epiphysis. It is often associated with separation of the lower epiphysis of the fibula or with fracture of the lower extremity of that bone. The astragalus follows the tibial epiphysis in its displacement, whether this be backward or, as in the case of associated fracture or epiphyscal separation of the lower end of the fibula, outward. In either case, the injury simulates dislocation at the ankle-joint. The lower epiphysis includes the entire articular portion of the lower end of the bone, including the articular surface for the fibula, and joins the diaphysis at the eighteenth year.

It is noteworthy that, while in the upper limb the epiphyses adjacent to the elbow join their diaphyses earlier than do the epiphyses at the opposite ends of the respective bones, in the lower limb the reverse condition obtains, the epiphyses adjacent to the knee uniting with their diaphyses at a later date than do those at the opposite ends of the bones concerned.

Disease of the tibia is quite common, the bone's vulnerability in this respect being due at least in large measure to anatomical features, such as its exposed position, which renders it subject to repeated slight or severe traumatisms, the relation of the size of the bone at its point of smallest diameter—the junction of the lower and middle thirds—to the strain it must bear, and the arrangement of its blood-supply in relation to its dependent position, the nutrient artery entering the bone in its upper third. It is a favorite seat among bones for infective processes such as tuberculous and syphilitic inflammations, and quite frequently becomes the seat of osteitis following typhoid fever. *Tuberculosis* may affect any part of the bone; *Brodie's abscess* is an abscess of tuberculous origin occurring in the head of the tibia. *Rickets* seems to have a special predilection for the tibia, the distortions of the bone which this disease produces being exceedingly common. The tibia is also a favorite seat of *sarcoma*, which occurs most commonly at the upper end of the bone.

The Fibula.—*Fractures of the fibula* alone are not very frequent from direct violence because of the protection afforded by the tibia and the related muscles. As seen in Fig. 135, the fibula is situated rather back of the plane of the tibia and is well protected in front therefore—the aspect of the limb most exposed to direct injury—by the tibia as well as by the anterior tibial and peroneal groups of muscles. When such fractures do occur the displacement is slight, the tibia acting as a splint, and also because of the elasticity of the fibula. Fracture from indirect force usually occurs in the *lower third* of the bone, constituting *Pott's fracture* when associated with either rupture of the internal lateral ligament of the ankle-joint or fracture of the internal malleolus. Reference to the articulated skeleton, showing the relation of the fibula to the astragalus and to the external lateral ligament, will make apparent the effect upon the lower end of the fibula of forcible eversion or abduction of the foot, especially when pressure upward is at the same time exerted upon the astragalus, and also the manner in which leverage will bring great inward strain upon the lower part of the fibular shaft; this strain is of course augmented by the giving way of the deltoid ligament or of the inner malleolus. The characteristic deformity of Pott's fracture is what might be expected—depression at the seat of fracture with overlapping of fragments and marked eversion of the foot with undue prominence of the inner malleolus. Almost needless to say, it is necessary to strongly invert and adduct the foot to restore the lower fragment to normal position either for the purpose of eliciting crepitus or for treatment.

In fractures of the tibia and fibula together the location of the line of fracture of the fibula is determined by that of the tibia, more marked shortening, due to the leg muscles, and eversion of the foot, due to its weight, being present than in fracture of either bone alone.

THE SOLE OF THE FOOT.

THE SURFACE ANATOMY.

The **skin** of the sole is unusually thick and is devoid of hairs and sebaceous glands as in the case of the skin of the palm. A posterior convexity corresponding to the heel and an anterior convexity corresponding to the metatarso-phalangeal joint of the great toe form the

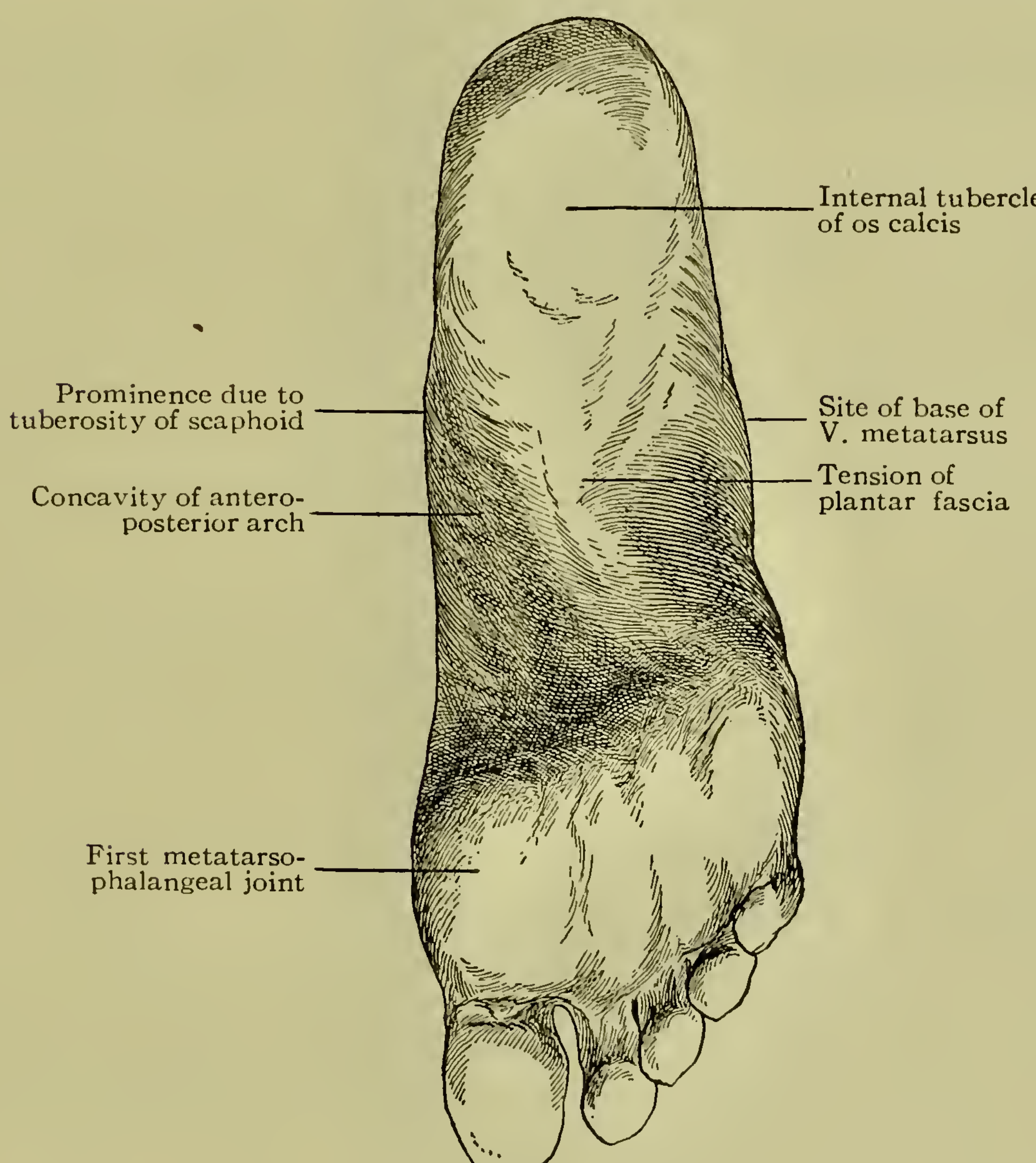

FIG. 139.—Surface anatomy of sole.

chief points of support of the foot. Between these regions the sole is slightly concave, this concavity being considerably accentuated along the inner aspect to correspond with the antero-posterior arch constituted by the bones of the foot.

DISSECTION.

An incision having been made along the outer border of the sole and one along its inner border, the two connected with each other by an incision around the circumference of the heel, the reflection of the

skin should be begun at the latter place. In dissecting the skin its close connection with the underlying superficial fascia will be noted as well as its toughness and thickness. The dissection having been carried to the toe-clefts, a transverse incision may be made and the flap detached. A longitudinal incision along the median line of each toe should be made, the toes being held in position by nails or tacks driven one through the extremity of each toe, and the skin reflected toward either side of the toe.

THE SUPERFICIAL FASCIA.—The superficial fascia, rather plentifully supplied with fat, is now exposed. The **internal calcanean,** a cutaneous branch of the posterior tibial nerve, the origin of which from the posterior tibial has been noted, may be traced in its ramifications around the convexity of the heel and across the back part of the sole accompanied by the **internal calcanean branches** of the posterior tibial artery (Fig. 141). A few cutaneous filaments along the outer border of the sole coming from the external saphenous nerve and the **calcanean** and **cutaneous branches** of the external plantar artery and a few nerve filaments along the inner border coming from the internal saphenous nerve, as well as **cutaneous branches** of the internal plantar artery, may be found. The **plantar digital branches** of the internal and external plantar nerves as also the digital arteries supplying the adjacent sides of the several toes may be found upon the toes at this stage of dissection, but their position immediately back of the toe-clefts is between the subdivisions of the deep or plantar fascia rather than within the superficial fascia (Fig. 141). The superficial fascia may now be removed, its thickness being noted, this feature being related to its importance as a cushion for the foot. This exposes the deep fascia.

THE DEEP OR PLANTAR FASCIA (aponeurosis plantaris).—This fascia upon the removal of the superficial fascia is seen to consist of a **central** opaque thickened portion and of two **lateral** thin and semitransparent portions (Fig. 140). The **inner lateral portion of the plantar fascia** covers the abductor hallucis muscle chiefly as well as the other muscles on the inner border of the sole. It is attached behind to the internal annular ligament and is continuous laterally with the dorsal fascia. It may now be removed in order to expose these muscles. The **outer lateral portion of the fascia** covers the abductor minimi digiti. It is continuous laterally with the dorsal fascia and is attached in front to the base of the fifth metatarsus. It may also now be removed. In removing these lateral parts of the fascia it will be seen that they are connected with the borders of the central slip and that intermuscular septa pass from the two lines of connection to the deeper parts of the sole. The **central portion of the plantar fascia** appears as a layer which is narrow behind where it is attached to the back part of the under surface of the os calcis (its inner tubercle), and wide in front where

it divides into *five bands* or slips for the five toes. Between these slips are seen the digital nerves, the digital arteries and the lumbricales tendons passing to the corresponding clefts between the toes. Each individual slip will be found to divide into two slips which are bound

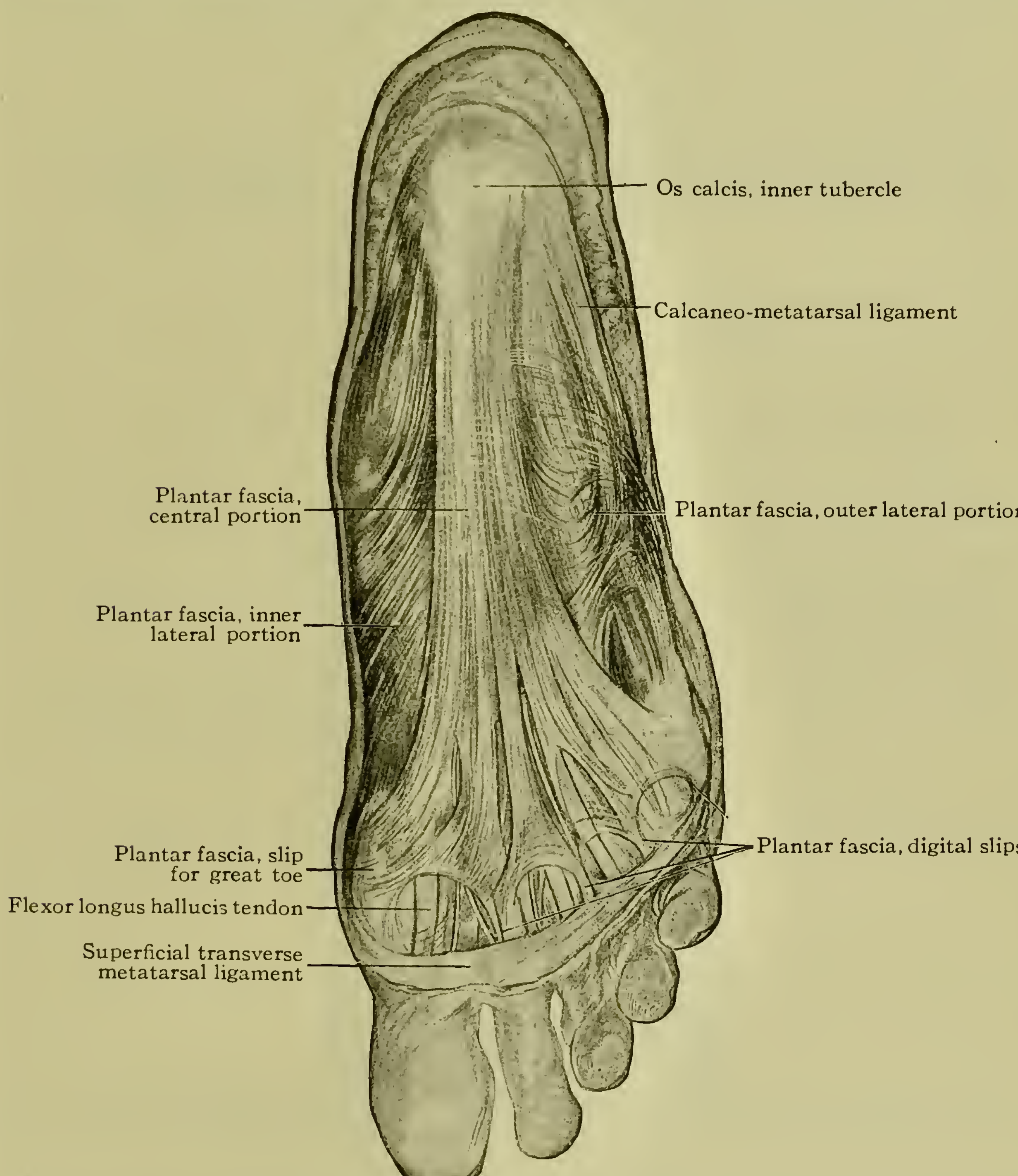

FIG. 140.—Superficial dissection of sole of right foot (subject lying on belly), showing plantar fascia.

down at the position of the metatarso-phalangeal joint to form an archway for the tendons which pass to the respective toes and to give off a superficial stratum to be inserted into the skin. The digital nerves and vessels mentioned should be picked up in the intervals between the slips and traced to the toe-clefts and the division of the digital

nerve and artery into two branches for the supply of adjacent sides of the corresponding toes should be noted and these branches worked out (Fig. 141). The central plantar fascia may be reflected by making a transverse incision in front of the tubercles of the os calcis (Fig. 142) and detaching the fascia carefully from the underlying structures and

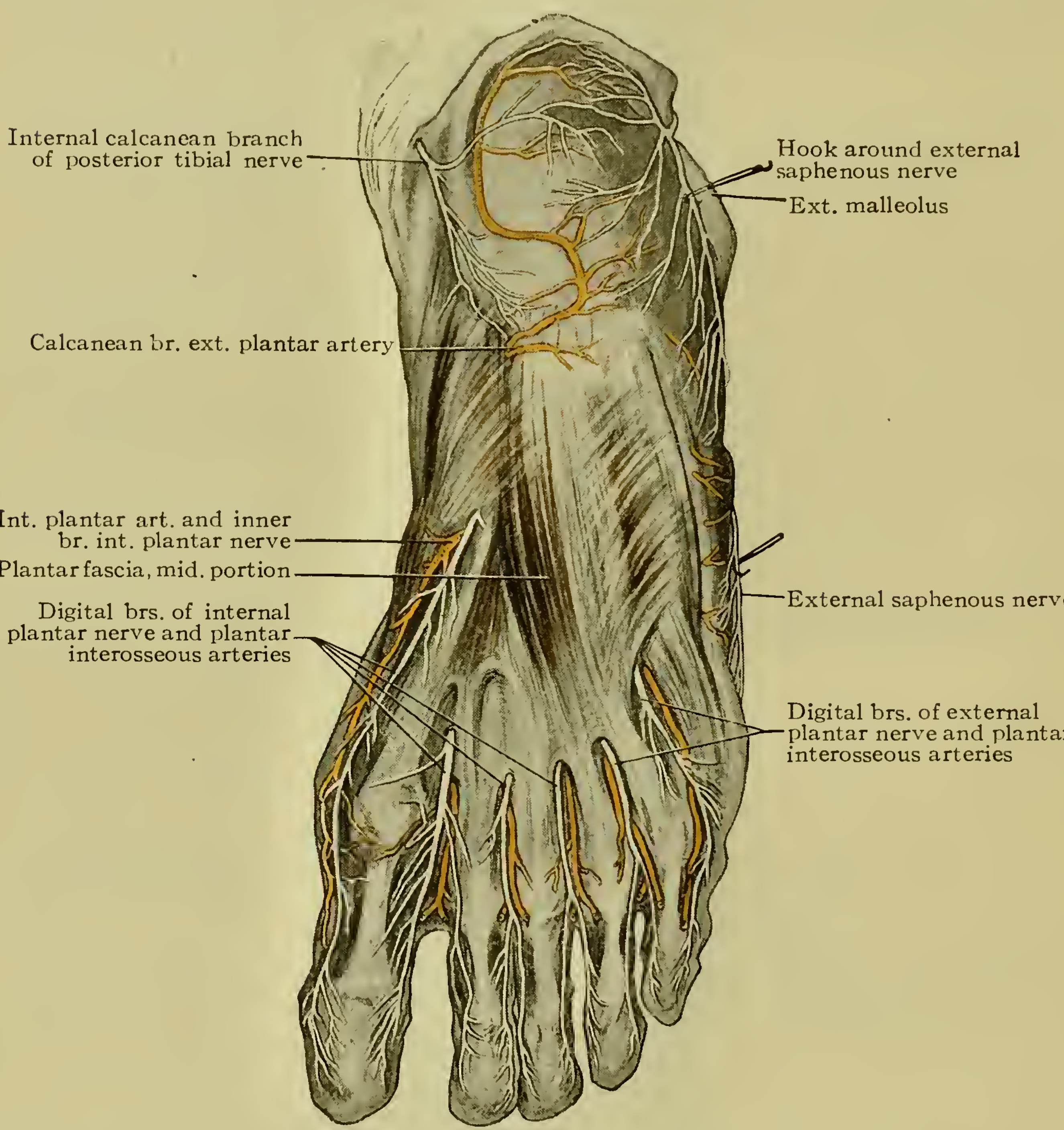

FIG. 141.—Superficial dissection of sole, showing plantar fascia and the relation of digital arteries and nerves to its subdivisions.

reflecting it forward. The dissector must avoid taking up with the back part of the plantar fascia the underlying muscle, the flexor brevis digitorum, which has part of its origin from the deep surface of the fascia and is, therefore, closely connected with it. This will demonstrate its continuity with the two deep septa of fascia mentioned above, these septa with the central portion of the fascia enclosing the muscles in the central part of the sole.

The denseness of the central slip of plantar fascia is directly related to its function in helping to maintain the antero-posterior arch of the foot. If this fascia becomes unduly contracted, as sometimes happens, this arch is accentuated, constituting the condition known as **talipes cavus** or **arcuatus**; if the plantar fascia be unduly relaxed the arch tends to give way, producing **talipes planus** (flat foot or splay foot). Incision of the plantar fascia for talipes cavus is done at its narrowest part, that is, just in front of the tubercles of the os calcis.

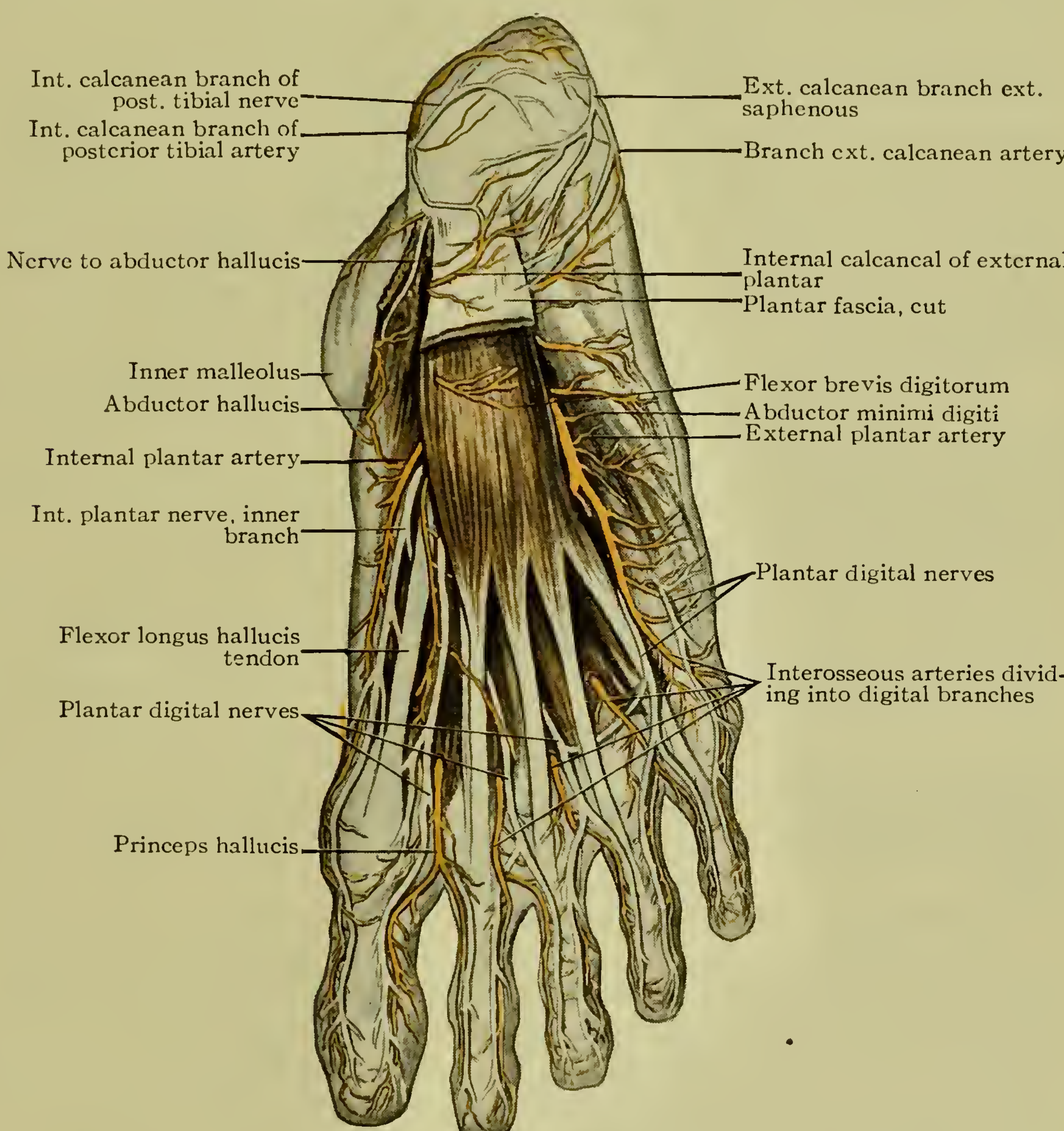

FIG. 142.—Superficial dissection of right sole, the superficial muscles undisturbed.

Upon the removal of the plantar fascia the *superficial layer of muscles* is exposed, consisting of the **abductor hallucis** on the inner side of the sole, the **abductor minimi digiti** on the outer side, and the **flexor brevis digitorum** in the central portion of the sole (Fig 142). Before disturbing these muscles such of the nerves and vessels as appear in the intervals between the muscles should be searched for and dissected. Back of the middle of the foot near its inner border the **internal plantar**

artery will be encountered emerging superficially between the abductor hallucis and the flexor brevis hallucis and passing forward toward the inner side of the great toe. This artery and its branches should be followed in their course forward to the inner side of the great toe. The **internal plantar nerve** accompanying this vessel should also be dissected in so far as it appears at this stage and as much of the digital nerves and digital vessels as can be found without disturbance of the muscles and tendons should be dissected and traced forward to their distribution upon the toes. At the outer border of the flexor brevis digitorum (Fig. 142), a little back of the middle of the sole, the **external plantar nerve** and **artery** make their appearance, from which point superficial branches of each pass forward toward the cleft between the fourth and fifth toes and the outer side of the little toe. Farther back other cutaneous branches of the external plantar nerve emerge from beneath the outer border of the flexor brevis digitorum.

The Abductor Hallucis (Fig. 142).—**Origin,** the inner tubercle of the os calcis, the internal annular ligament and the plantar fascia; **insertion,** the inner side of the base of the first phalanx of the great toe; **nerve-supply,** the internal plantar nerve (fourth and fifth lumbar and first sacral); **action,** abduction and flexion of the great toe.

This muscle is separated from the flexor brevis digitorum by one of the septa of the plantar fascia. Displacing from the surface of the muscle the nerves and vessels already isolated, the muscle should be cleared of connective tissue, when it will be seen to be made up of numerous muscular bundles separated by fibrous septa, the bundles converging to a tendon which passes forward along the inner side of the inner head of the flexor brevis hallucis, with which it is frequently closely connected and from which it should be separated by the handle of the scalpel.

The Flexor Brevis Digitorum (Fig. 142).—**Origin,** the front of the inner tubercle of the os calcis and the deep surface of the central plantar fascia; **insertion,** by four tendons into the sides of the middle phalanges of the four lesser toes after having divided to permit of the passage of the tendons of the long flexor; **nerve-supply,** the internal plantar nerve (fourth and fifth lumbar and first sacral); **action,** flexion of the middle phalanges of the four lesser toes.

This muscle should be separated from the abductor hallucis upon its inner side, and the abductor minimi digiti upon its outer side, and should be carefully denuded of connective tissue, each tendon being followed to its termination. Each tendon at the proximal portion of the proximal phalanx splits to permit of the passage of the corresponding tendon of the long flexor, when the two portions reunite to form a bed for the reception of the long tendon, after which the single slip again divides into two parts which are inserted into the lateral surfaces of

the second phalanx. From this arrangement of its tendons this muscle is called the *flexor perforatus* and corresponds with the flexor sublimis digitorum of the upper extremity.

THE ABDUCTOR MINIMI DIGITI (Fig. 142).—**Origin,** the outer tubercle of the os calcis and the surface of the bone between the tubercles, the plantar fascia and the intermuscular septum; **insertion,** into

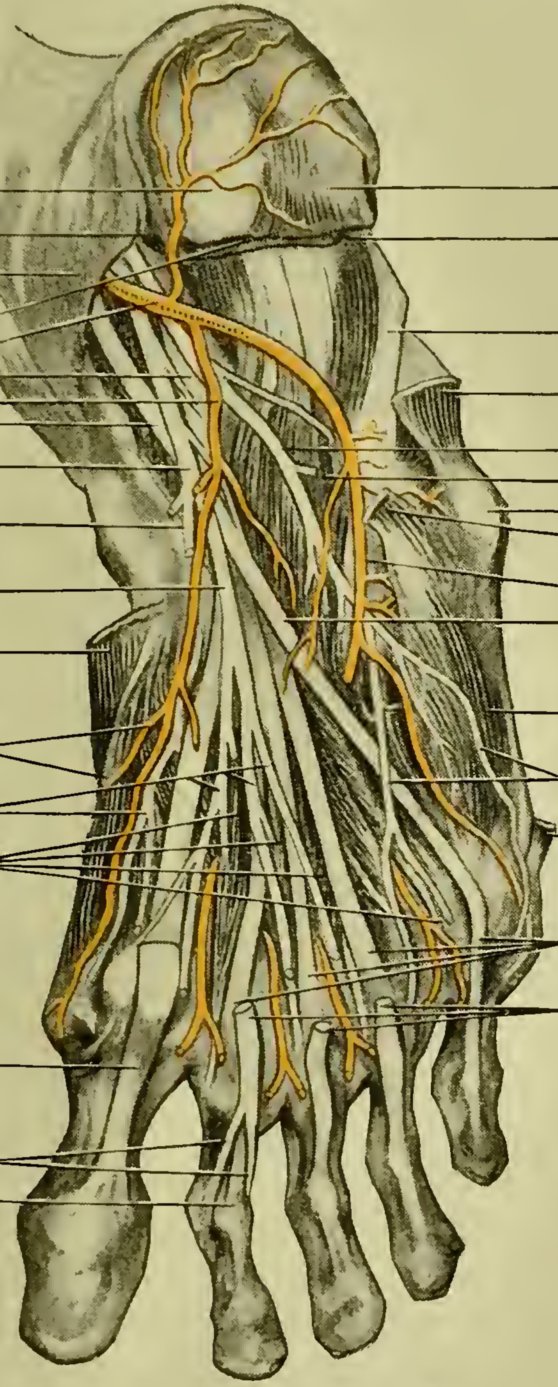

FIG. 143.—Dissection of right sole, showing structures exposed by removal of superficial muscles.

the outer side of the first phalanx of the little toe; **nerve-supply,** the external plantar nerve (first and second sacral); **action,** abduction and flexion of the little toe.

Having denuded this muscle and traced its tendons to its point of insertion the dissector is ready to proceed to the consideration of the second layer of muscles. The flexor brevis digitorum should be divided

near its origin and reflected forward, raising it gently and looking for its nerve of supply which is from the external plantar and which enters its deep surface. The abductor minimi digiti should also be cut close to its origin and reflected forward, the dissector avoiding injury to the external plantar nerve in doing so. The abductor hallucis should be reflected by detaching it from the inner tubercle of the os calcis, the internal annular ligament and its points of fascial origin, avoiding injury to the underlying plantar vessels and nerves. This exposes the *second layer of muscles* as well as the external plantar artery in part and the external plantar nerve. The respective terminations of the posterior tibial artery and nerve and their division into the terminal branches are likewise exposed. Beginning at the bifurcation of the posterior tibial artery this vessel should be cleaned with due care to avoid injury to associated nerves, and the internal plantar branch should be followed forward so as to complete the cleaning of this vessel.

The Internal Plantar Artery.—The internal plantar (a. plantaris medialis), the smaller of the two plantar vessels, passes forward from the space between the inner malleolus and the heel where it **arises** as a terminal branch of the posterior tibial, to the inner side of the ball of the great toe where it **terminates** by anastomosing with the inner digital branches of the princeps hallucis. This vessel gives off numerous *muscular*, *articular*, and *cutaneous branches* in its passage forward and lies at first along the inner side of the flexor accessorius muscle and the tendon of the long flexor of the great toe, being related by its deep surface to the short flexor of the toe and being covered in part by the abductor hallucis and then passes between the latter muscle and the short flexor of the toes to become superficial. Across the plantar surface of the first phalanx of the great toe it communicates with the princeps hallucis from the plantar arch.

The **surface line** of the internal plantar artery is one drawn from a point midway between the tip of the inner malleolus and the convexity of the heel to the under surface of the great toe.

The External Plantar Artery.—The external plantar artery (a. plantaris lateralis) (Fig. 143), **arising** as the larger of the two terminal branches of the posterior tibial, arches outward across the sole toward the base of the fifth metatarsal bone and then curves inward to the back part of the space between the first and second metatarsal bones. Its course is indicated, first, by a **surface line** from the middle of the space between the inner malleolus and the heel to the tuberosity at the base of the fifth metatarsal; and second, as the **plantar arch,** from the latter point to the back part of the first intermetatarsal space. Its **branches** (see also p. 255) in the *first part* of its course are the *internal calcanean branches* near its beginning going to the inner part of the heel and various *muscular* and *cutaneous branches* (p. 274). Its **relations**

in this part of its course are, by its deep surface with the flexor accessorius and farther along with the flexor brevis minimi digiti, coming to lie in the interval between the flexor brevis digitorum and the abductor minimi digiti after it emerges from under cover of the flexor brevis digitorum (Fig. 142). In the second part of its course, in which it constitutes the **plantar arch** (arcus plantaris), it is situated much more deeply and will be traced at a later stage of the dissection.

What may be called the *second layer of the muscles of the sole* includes the accessory flexor and the four lumbrical muscles, to which may be added the tendon of the long flexor of the toes.

The Flexor Accessorius (Fig. 143).—**Origin,** the *outer head*, from the under surface of the os calcis in front of the outer tubercle; the *inner head*, the larger, from the concave inner surface of the os calcis; **insertion,** the tendon of the long flexor (Fig. 143); **nerve=supply,** the external plantar nerve (first and second sacral); **action,** to assist in flexion of the four lesser toes and to correct the obliquity of the pull of the long flexor.

Having denuded this muscle it may be carefully elevated in order to demonstrate it completely.

The Lumbricales (Fig. 143).—**Origin,** the adjacent sides of the tendons of the long flexor between which they are placed, except the first or inner lumbrical which arises from the inner side of the tendon for the second toe; **insertions,** the aponeuroses of the tendons of the extensor longus digitorum for the corresponding toes upon the inner side in each case; **nerve=supply,** the *first* and sometimes the *second*, from the internal plantar nerve, the *third* and *fourth*, counting from the inner side, and sometimes the *second*, from the external plantar nerve; **action,** to assist in flexion of the proximal phalanges and extension of the second and third phalanges of the four lesser toes.

The **tendon of the long flexor of the toes** may now be more fully examined as to its course through the sole. Being situated in front of the tendon of the flexor longus hallucis in the interval between the inner malleolus and the heel, after reaching the sole of the foot it crosses superficially the latter tendon and passes obliquely across the sole to the middle of the latter when it divides into four tendons for the four lesser toes. These tendons, as indicated above, perforate the tendons of the short flexor (p. 278) and pass beyond them to be inserted into the bases of the third phalanges of the toes (Fig. 143). This muscle is, therefore, called the *flexor perforans* and is analogous to the flexor profundus of the upper extremity. The tendon of the muscle may be divided at the point where it enters the sole of the foot. The flexor accessorius may be divided near its insertion into the long flexor tendon and this latter tendon with the lumbricales may be reflected forward. This exposes what may be called the *third layer of muscles of the sole*

of the foot, which group includes the short flexor of the big toe, its adductor or oblique adductor, and its transverse adductor, as well as the short flexor of the little toe.

The Flexor Brevis Hallucis (Fig. 144).—**Origin,** by a pointed process from the sheath of the tendon of the tibialis posticus and from the under surface of the cuboid and the adjacent portion of the external

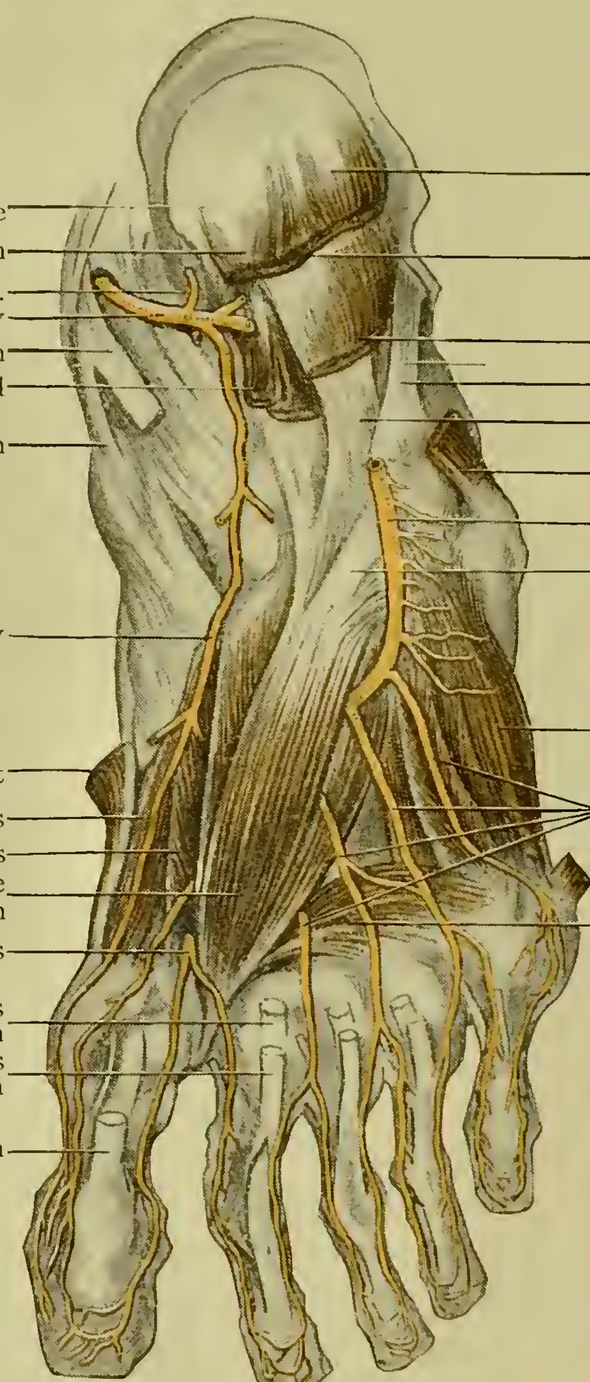

Fig. 144.—Deep dissection of sole of right foot.

cuneiform bones; **insertion,** by two heads into the inner and outer sides of the first phalanx of the great toe; **nerve-supply,** for the *inner portion*, the internal plantar nerve, and for the *outer head*, the external plantar; **action,** flexion of the big toe.

The *outer portion* of this muscle, that arising from the cuboid bone and inserted into the outer side of the first phalanx of the great toe,

is regarded, upon the basis of its development and nerve-supply, as a plantar interosseous muscle.

In dissecting this muscle the student will observe that the tendon of the long flexor of the great toe is placed between the two heads of insertion and that the inner head as it passes over the metatarso-phalangeal articulation has within it a sesamoid bone (Fig. 145) and is inserted in association with the tendon of the abductor hallucis; and that the outer head, likewise containing a sesamoid bone, is inserted in connection with the tendons of the oblique and transverse adductors.

THE ADDUCTOR OBLIQUUS HALLUCIS (adductor hallucis, caput obliquum).—**Origin,** the bases of the second, third and fourth metatarsal bones and the sheath of the peroneus longus tendon; **insertion,** into the outer side of the first phalanx of the great toe in company with the preceding muscle and the following one; **nerve-supply,** the external plantar nerve (fifth lumbar and first and second sacral); **action,** adduction and flexion of the great toe (Fig. 144).

In cleaning this muscle the dissector will avoid injury to the arteries along its outer border as well as to the other vessels he may encounter.

THE TRANSVERSUS PEDIS OR ADDUCTOR TRANSVERSUS HALLUCIS (adductor hallucis, caput transversum).—**Origin,** the inferior aspects of the metatarso-phalangeal joints of the third, fourth and fifth toes (Fig. 144); **insertion,** the outer side of the base of the first phalanx of the great toe; **nerve-supply,** the external plantar nerve (fifth lumbar and first and second sacral); **action,** adduction of the great toe. This muscle is not infrequently so small as to be almost rudimentary.

THE FLEXOR BREVIS MINIMI DIGITI (Fig. 144).—**Origin,** the base of the fifth metatarsal bone and the sheath of the peroneus longus tendon; **insertion,** the base of the first phalanx of the little toe and the distal end of the fifth metatarsus; **nerve-supply,** the external plantar nerve (second sacral); **action,** flexion of the little toe.

These muscles having been denuded and studied may be reflected by incision of each near its origin. This will expose the so-called *fourth layer of muscles*, the dorsal and plantar interossei, and the second part of the external plantar artery.

The **plantar arch** (arcus plantaris), the deep part of the external plantar artery (Fig. 145), describing a course from a point near the base of the fifth metatarsal bone to the back part of the first metatarsal space,—its **surface line** being one connecting these points,—should now be dissected. Following it to its termination, the dissector will note that it unites with the communicating branch of the dorsalis pedis, which branch reaches the sole through the back part of the space between the first and second metatarsal bones. This anastomosis constitutes the plantar arch.

The **branches of the plantar arch** are the three *posterior perforating branches* (which sometimes arise from the plantar interosseous or digital arteries), *articular branches* from the proximal aspect of the arch for the tarsal joints, and six *digital* or *plantar interosseous arteries* (aa. metatarsæ plantares).

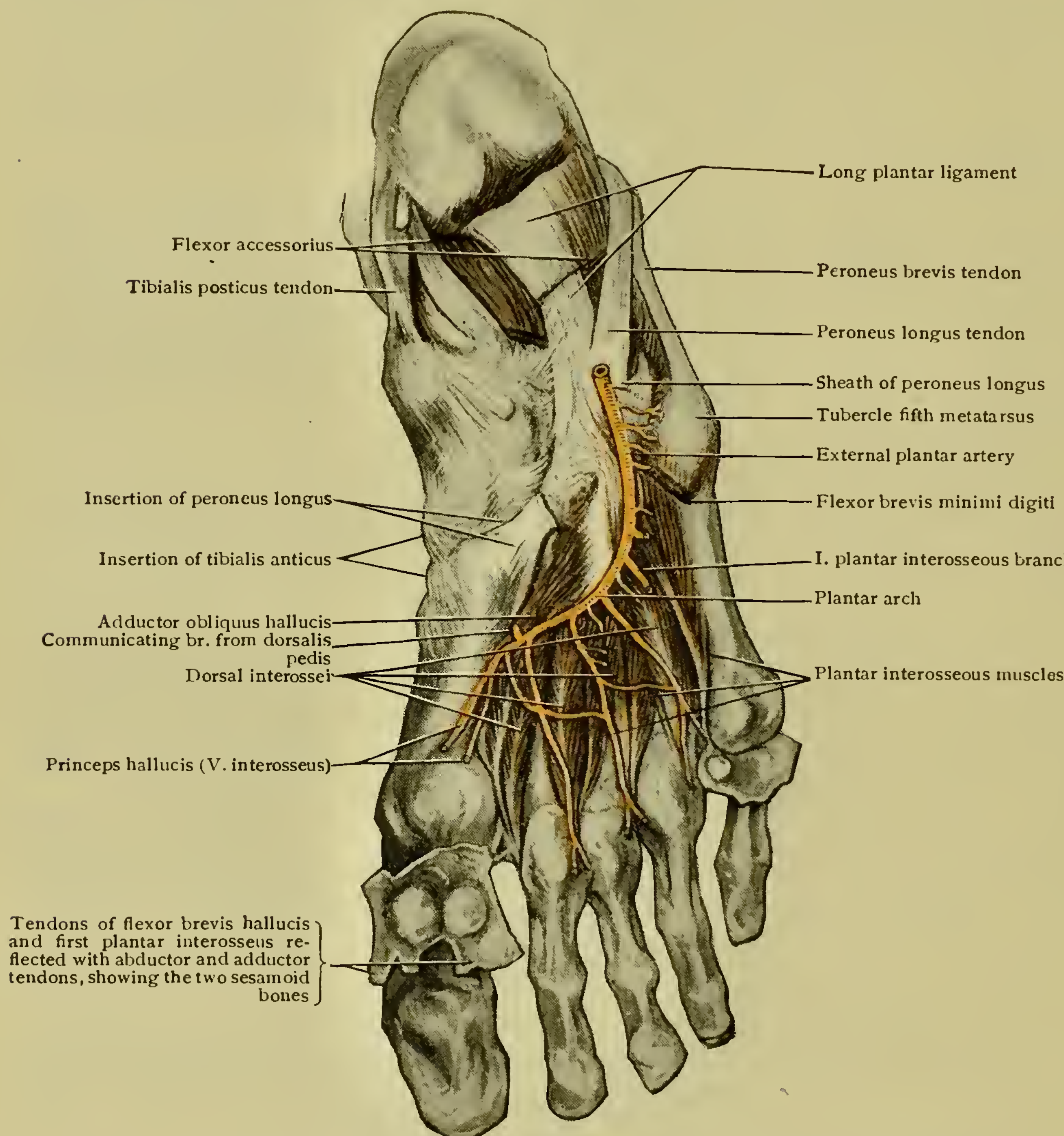

Fig. 145.—Deep dissection of sole of right foot, showing interossei and plantar arch.

The **digital** or **plantar interosseous branches** include the four digital arteries arising from that part of the arch which is constituted by the external plantar artery and the two digital branches arising from that part of it which is formed by the communicating branch of the dorsalis pedis. These six digital arteries are destined for the supply of the four toe-clefts, the outer side of the little toe and the inner side of the big toe. The two digital branches from the communicating branch of the dorsalis pedis sometimes arise by a single trunk which is designated

the **princeps hallucis.** From the digital arteries near their origins are derived the three *posterior perforating branches* (see above) which pass through the three outer intermetatarsal spaces to the dorsal surface of the foot, anastomosing with the dorsal interosseous branches of the metatarsal artery. The four *anterior perforating* branches of the digitals (the outermost and the innermost digitals excepted) arise near the toe-clefts and pass to the dorsum of the foot through the anterior portions of the metatarsal spaces. The digital (plantar interosseous) arteries, except the outermost and the innermost, each divide at the corresponding toe-cleft into two *plantar digitals* or *collateral digitals* for the adjacent sides of the toes (Fig. 144). These digital vessels should be traced to their terminations as they ramify along the sides of the respective toes to which they are distributed in company with the digital nerves.

The **relations of the plantar arch,** as will have been seen, are by its *deep aspect* with the proximal ends of the second, third and fourth metatarsi and the interosseous muscles and by its *superficial surface* with the tendons of the long flexor of the toes and their associated lumbricales, and the oblique adductor of the great toe, being more remotely covered by the flexor brevis digitorum, the central slip of the plantar fascia, the superficial fascia and the skin.

Because of its deep situation the plantar arch if *wounded* may be best reached for ligation from the dor al aspect of the foot, to accomplish which resection of one or more of the metatarsal bones is necessary. It is noteworthy that the blood-supply of the foot, as that of the lower extremity generally, is considerably less free than the blood-supply of the corresponding parts of the upper extremity. For this reason gangrene is more apt to follow obstruction of the circulation, as by wound or embolus, in the case of the lower extremity than in the case of the upper.

The Internal Plantar Nerve (n. plantaris medialis).—The internal plantar nerve is the larger of the terminal branches of the posterior tibial nerve, arising from the latter trunk beneath the abductor hallucis muscle in the interval between the inner malleolus and the heel (Fig. 138). Passing forward the nerve goes between the abductor hallucis and the flexor brevis digitorum in company with the internal plantar artery (Fig. 143) and deviating outward passes between the flexor brevis digitorum and the flexor brevis hallucis, where it divides into its two **terminal branches.** The **branches** arising prior to its division are *cutaneous branches* to the inner border of the sole, *articular branches* to the neighboring joints and *muscular branches* to the abductor hallucis and flexor brevis digitorum.

The **inner** (medial) **terminal branch** passes forward between the abductor hallucis and the inner portion of the plantar fascia, piercing the latter at the ball of the great toe, to the inner side of which digit it is distributed—after contributing a twig to the inner head of the short flexor of the big toe—as one of the *digital nerves.*

The **outer** (lateral) **terminal branch** passing forward and outward soon divides into the three *digital nerves* (nn. plantares communes) each of which divides near the toe-clefts into two *collateral digital nerves* (nn. digitales plantares proprii) for the cutaneous supply of the adjacent sides respectively of the first and second, the second and third, and the third and fourth toes. From the terminal parts of the collateral digital branches small twigs pass to the dorsal surfaces of the ends of the toes. The first or innermost of these three digital nerves gives a muscular branch to the first lumbrical muscle, the second one sometimes supplies the second lumbrical, while the third communicates with the external plantar. The digital branches as well as the trunk of the internal plantar having been followed in the dissection of the sole up to this stage, it only remains to clear away any remaining connective tissue which may obscure any of the branches and to identify and trace the muscular and cutaneous branches. The **muscular** branches, as noted above, are distributed to the abductor hallucis (its deep surface), to the inner head of the flexor brevis hallucis, to the flexor brevis digitorum and to the innermost lumbrical muscle and sometimes to the second lumbrical. The cutaneous branches, other than the digital nerves mentioned above, were encountered in the dissection of the superficial fascia as filaments distributed to the skin along the inner border of the sole and to the region just in front of the heel. It will thus be seen that the distribution of the internal plantar nerve in the foot corresponds with that of the median nerve in the hand; that is, it supplies digital (cutaneous) branches to the greater number of toes—three and a half—and muscular branches to the less number of muscles as compared with the external plantar nerve.

The External Plantar Nerve (n. plantaris lateralis).—The external plantar nerve (Fig. 143), the smaller of the two terminal branches of the posterior tibial nerve, arises from the latter in the space between the inner malleolus and the heel, from which point it passes obliquely forward and outward across the sole of the foot in relation with the deep surface of the flexor brevis digitorum and the superficial surface of the flexor accessorius, in company with the external plantar artery, and appears in the interval between the flexor brevis digitorum and the abductor minimi digiti (Fig. 142), where it divides into its two **terminal branches,** the superficial and the deep. Beginning at the origin of the nerve to follow its course, any remaining connective tissue should be removed and the **branches** sought for in their order: first, the *cutaneous branches*, which become superficial near the outer border of the sole, distributing branches to the skin of this region, and then successively the *muscular branches* to the flexor accessorius, and the abductor minimi digiti. The **superficial** or **cutaneous terminal branch** (ramus superficialis) divides into two *digital* or *common digital nerves*,

the *outer* of which after supplying *muscular branches* to the flexor brevis minimi digiti and to the interosseous muscles of the fourth space, continues as a cutaneous *digital nerve* to the outer side of the little toe; the *inner digital branch* divides into *two collateral digitals* for the adjacent sides of the little and fourth toes. Like the digital terminations of the internal plantar nerve, these nerves send filaments to the distal portion of the dorsal surfaces of their toes. The **deep** or **muscular branch** (ramus profundus) (Fig. 143) accompanies the deep part of the external plantar artery between the flexor tendons and the adductor obliquus hallucis, which are superficial to it, and the interossei, which are deeper, and distributes *muscular branches* to the dorsal and plantar interossei, except those of the fourth space, the three outer lumbricales, the adductor transversus hallucis, the adductor obliquus hallucis and the outer head of the flexor brevis hallucis (first plantar interosseous—see p. 282).

The distribution of the external plantar, therefore, corresponding with that of the ulnar in the hand, is to one and a half toes and all of the muscles of the sole except those mentioned above as being supplied by the internal plantar.

The dissector will now have reached the *fourth layer of muscles*, namely, the plantar and dorsal interossei.

Interossei Plantares.—The plantar interossei (Fig. 145) are three in number—or four, including as the *first* the outer head of the flexor brevis hallucis (p. 282)—and are found in, or rather beneath, the spaces between the metatarsal bones of the second and third, of the third and fourth, and of the fourth and fifth toes (the first occupying the first intermetatarsal space). **Origin,** the three outer muscles from the bases and inner sides of the shafts of the third, fourth and fifth metatarsal bones; **insertion,** by narrow tendons into the inner sides of the same toes from whose metatarsi they respectively arise, blending with the aponeuroses of the extensor tendons of those toes. For the origin and insertion of the first plantar interosseous see p. 282. **Nerve-supply,** the external plantar nerve (first and second sacral); **action,** adduction of the toes into which they are inserted (the first, third, fourth and fifth) toward the mid-line of the second toe, corresponding with the palmar interosseous muscles of the hand—with the modification that those of the hand adduct the fingers into which they are inserted toward the mid-line of the third digit—and extension of the second and third phalanges and flexion of the first phalanx.

Interossei Dorsales (Fig. 145).—These muscles are four in number and are situated in the spaces between the five metatarsal bones. **Origin,** the adjacent sides of the metatarsi with which they are in relation; **insertion,** the bases of the first phalanges of the second, third and fourth toes and the aponeuroses of the extensor tendons, the tendon of the first interosseous muscle passing to the inner side of the second

toe, that of the third muscle passing to the outer side of the second toe, while those of the third and fourth muscles pass to the outer sides of the third and fourth toes; **nerve-supply,** the external plantar nerve (first and second sacral); **action,** to abduct the toes (except the great and the little toe) from the mid-line of the second toe; to aid in flexion of the proximal phalanges and in extension of the second and third phalanges by virtue of their insertion into the aponeuroses of the extensor tendons.

Having completed the dissection to this stage, the dissector should clear the surface of the **sheath of the tendon of the peroneus longus** (Fig. 145) as the latter passes obliquely across the sole from the tuberosity on the base of the fifth metatarsal bone inward and forward to the internal cuneiform and the base of the first metatarsal. The sheath may then be opened and the tendon inspected and note made of the articular surface on the outer aspect of the cuboid bone round which the tendon turns.

The **long plantar** or **calcaneo-cuboid ligament** (Fig. 145) should be cleaned and its attachment posteriorly to the inferior surface of the os calcis, and anteriorly to the forepart of the cuboid bone on its under surface, should be noted, as well as the fact that the anterior fibres of this ligament, bridging over the groove on the under surface of the cuboid, constitute the sheath for the peroneus longus tendon.

Paralysis of the internal popliteal nerve from traumatism is much rarer than that of the external popliteal because of its less exposed situation. It may be caused by the pressure of tumors in the popliteal space or by aneurism. The condition is manifested by loss of the power of extension and impairment of the power of adduction and inversion of the foot and of flexion, adduction and abduction of the toes, the foot being drawn into the position of talipes calcaneus and the toes being over-extended (claw foot or *pied en griffe*) in cases of long standing, from the unopposed action of the anterior group of leg muscles. The longitudinal arch of the foot suffers from loss of the supporting effect of the long flexor tendons. Impairment of sensation occurs on the posterior aspect of the leg (communicans poplitei), the outer side of the foot (external saphenous) and the plantar surface of the foot (internal and external plantar nerves).

Paralysis of the great sciatic nerve may be due to fractures of the pelvis, or of the upper end of the femur or to pelvic tumors. Its manifestations are those noted above for paralysis of its terminal branches, the internal popliteal and the external popliteal (p. 256), plus inability to perfectly flex the knee from loss of power in the biceps, semimembranosus and semitendinosus; a certain amount of flexion will still be possible from the action of the sartorius, gracilis and tensor fasciæ femoris.

Neuralgia throughout the sensory distribution of these nerves may be due to the same causes as those cited for the paralyses, pressure not sufficient to abolish the function of the nerve producing irritation which is reflected to its peripheral distribution or to the distribution of communicating nerves.

The dissection of the soft parts of the foot having been completed, the dissector should see that both the foot and the lower part of the leg are properly wrapped that the ligaments may be protected against drying out, and should then proceed to the dissection of the joints of the lower limb, beginning with the knee-joint.

THE ARTICULATIONS OF THE LOWER LIMB.

The hip-joint has been dissected; a description of it will be found on page 224.

THE KNEE-JOINT (articulatio genu).—The **articular surfaces** involved in this joint are the articular portions of the condyles of the femur,

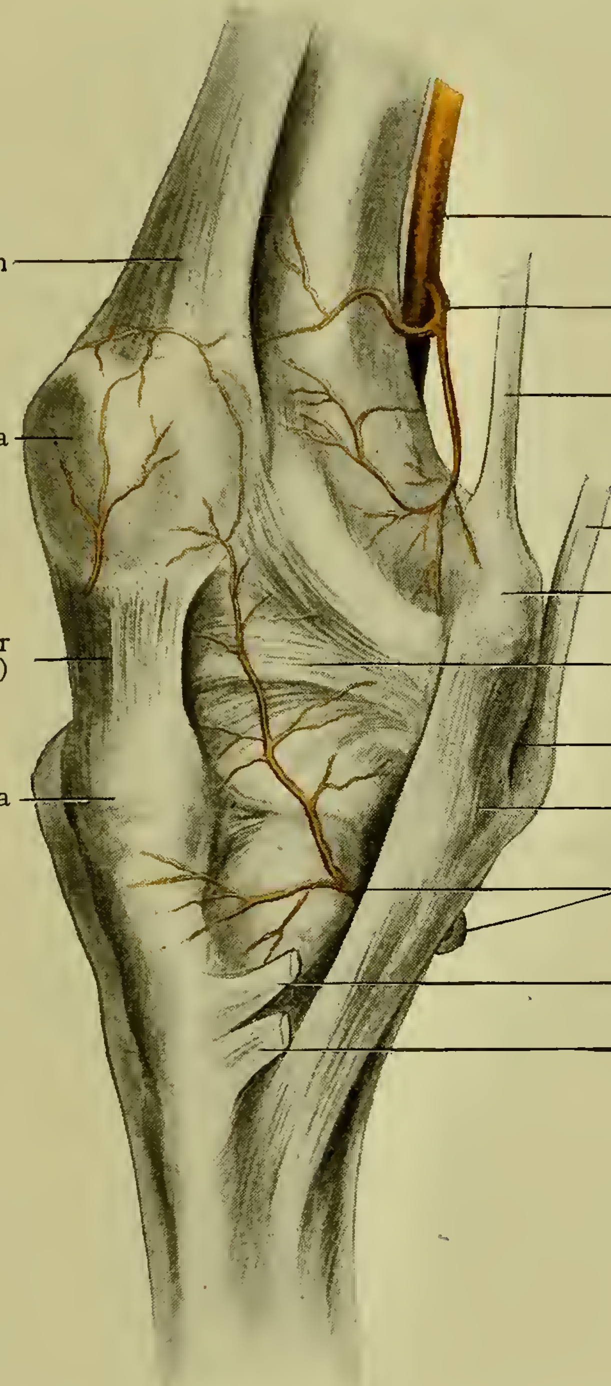

FIG. 146.—The right knee-joint, antero-internal aspect.

the articular surfaces of the patella and the articular depressions on the upper surface of the head of the tibia.

The **exterior ligaments** are the *anterior* or *ligamentum patellæ*, the *posterior* or *ligament of Winslow*, the *internal lateral*, the *long external lateral*, and the *capsular;* the **interior ligaments** are the *anterior* and the *posterior crucial*, the *semilunar cartilages*, the *transverse*, the *coronary* and the so-called *ligamentum mucosum*.

The **nerve-supply** includes a branch from the obturator, two or three branches of the popliteal (pp. 220 and 179), the tibial recurrent branch of the external popliteal, two branches of the anterior crural—one coming from the muscular branch to the vastus internus and one from the nerve to the vastus externus (Fig. 108).

The **blood-supply** is from the five articular branches of the popliteal, the anterior recurrent tibial, the external circumflex of the deep femoral and the deep branch of the anastomotica magna.

The parts of the capsule not hidden by the anterior and the lateral ligaments having been exposed by the removal of the investing aponeuroses of the vasti (p. 221), the dissector may give his attention to the individual bands on the front and lateral aspects of the joint.

The **anterior ligament,** the **ligamentum patellæ** (Fig. 146), stands out prominently on the anterior aspect of the joint, passing from the lower extremity of the patella to the lower half of the tubercle of the tibia. The anterior ligament, as previously demonstrated, is the central portion of the quadriceps extensor muscle, the lateral aponeuroses of which have already been severed from their connection with the lateral borders of the patella and of the patellar ligament (p. 221). The fat which intervenes between it and the front of the capsule may be cautiously removed; in this situation one sometimes finds a small bursa. The **infrapatellar bursa** is found between the tendon and the upper half of the tuberosity of the tibia.

The **internal lateral ligament** (lig. collaterale tibiale) (Fig. 146) is seen as a rather broad band attached above to the inner tuberosity of the femur and below to the inner surface of the upper part of the shaft of the tibia. This should be carefully isolated. The relation of the inferior internal articular artery (Fig. 146) has been noted. Its relation to the tendons of the sartorius, gracilis and semitendinosus has been seen (p. 221).

The **long external lateral ligament** (lig. collaterale fibulare), attached above to the external tuberosity of the femur and below to the head of the fibula, is seen upon the outer aspect of the joint (Fig. 147). At its lower end this ligament is embraced by the divisions of the tendon of the biceps, a bursa being interposed (Fig. 147). The inferior external articular artery and nerve and the tendon of the popliteus muscle pass under it.

The **short external lateral ligament,** situated much farther back (Fig. 149), is attached above to the lower and back part of the outer tuberosity of the femur and below to the styloid process of the fibula.

The **capsular ligament** is now exposed on the anterior and lateral aspects of the joint. The line of attachment of the capsule to the femur, to the tibia and to the patella should be noted (Fig. 148). The limb may now be turned to give access to the posterior surface of the joint.

The **posterior ligament** or **ligament of Winslow** (lig. popliteum obliquum) (Fig. 134) is attached above to the upper margin of the intercondyloid notch of the femur and below to the posterior margin of the head of the tibia, while it becomes continuous on each side with the lateral parts of the capsule. The surface of the posterior ligament

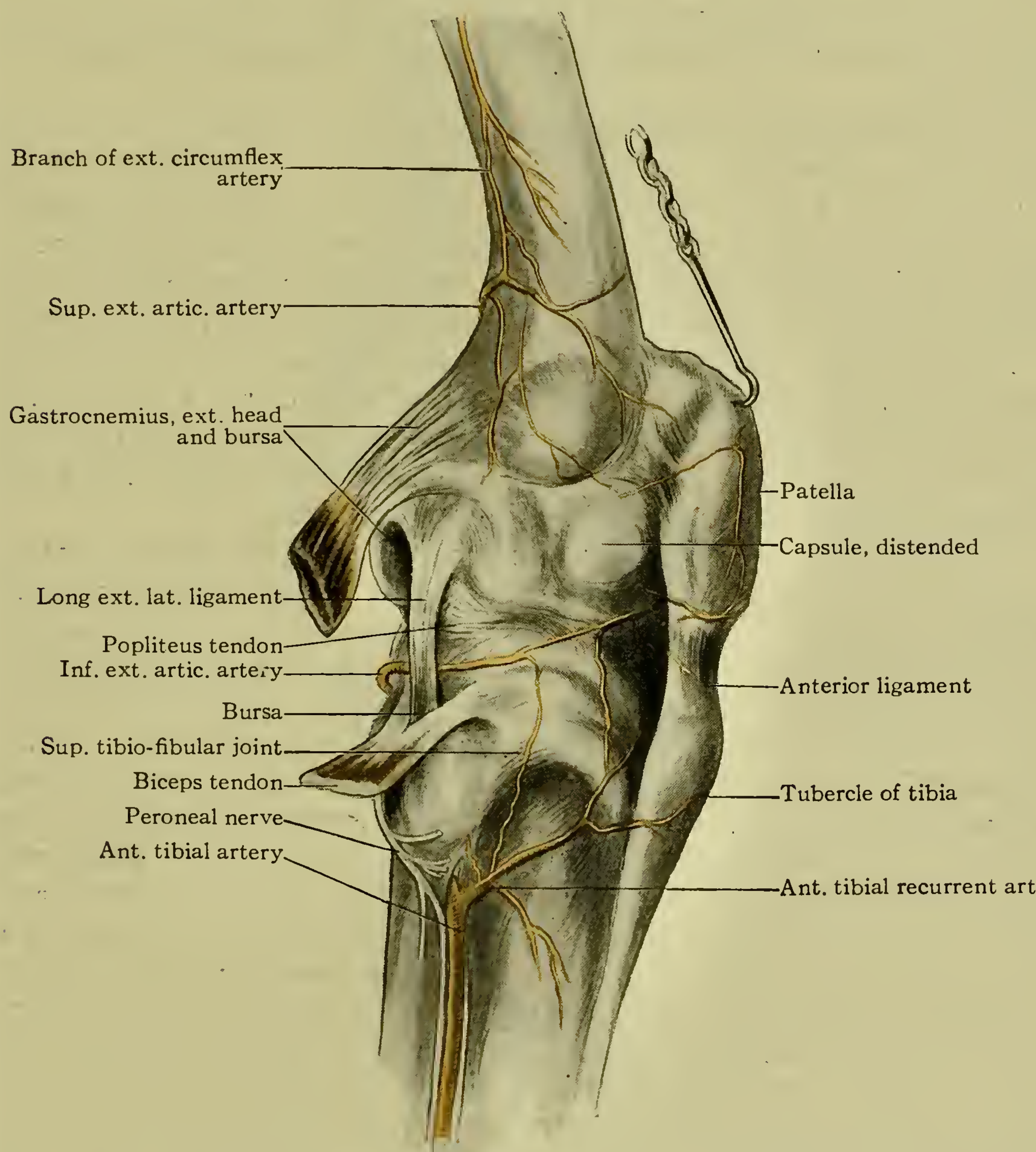

FIG. 147.—The right knee-joint, external aspect.

having been cleaned in the dissection of the popliteal space and the articular vessels and nerves found, the azygos articular artery from the popliteal and the azygos articular branch of the internal popliteal nerve should be noted as perforating the ligament near its centre. The reinforcement of this ligament by the strong expansion derived from the

tendon of the semimembranosus, its fibres passing upward and outward, is one of its conspicuous features.

The Interior of the Joint.—Again turning the limb, the attachment of the tendon of the rectus to the upper margin of the patella should be cut and the patella turned downward, incising the capsule along the line of its attachment to the margin of the articular surface of the bone. Continuing the displacement of the patella and its tendon, the infrapatellar bursa will be fully exposed and may be opened and examined (Fig. 148).

The **ligamentum mucosum** (plica synovialis patellæ) comes into view as the opening in the front of the capsule is enlarged—which should now be done and the leg should be fully flexed—and appears as a triangular band of synovial membrane, springing from that membrane where it lines the anterior and lower part of the capsule, and passing upward to be attached to the intercondyloid notch of the femur.

The **ligamenta alaria** (plicæ alares) are likewise folds of synovial membrane; they pass from the sides of the ligamentum mucosum upward and laterally between the femur and the patella. The ligamentum mucosum is associated with the large triangular pad of fat found within the capsule but outside the synovial membrane.

The **semilunar cartilages** (meniscus medialis et meniscus lateralis) are apparent in this position of the joint as glistening white bands, each meniscus being curved to conform to the periphery of that articular surface of the tibia with which it is connected and therefore partaking of the individual peculiarities of the latter as to outline and relative size (Fig. 148). The cartilages are anchored, but not firmly, to the margins of the articular surfaces of the tibia by short vertical fibres derived from the capsule, constituting the **coronary ligaments.** The cartilages are connected with each other in front by the **transverse ligament,** a band passing between the convexities of their anterior surfaces. Each meniscus, being thicker at the periphery and fading to a thin edge at the opposite margin, serves to augment the concavity of the articular surface to which it is related. In addition to the attachments of the cartilages to the tibia by the coronary ligaments, the anterior and posterior extremities of each are attached to the depressions in front of and behind the spine of the tibia respectively. The **ligament of Wrisberg** is a strong band which passes from a point near the posterior extremity of the external cartilage obliquely upward and outward to the inner condyle in front of the attachment of the posterior crucial ligament to the latter. Movement of the leg upon the thigh will demonstrate the degree of mobility of the cartilages.

The **anterior** or **external crucial ligament** (lig. cruciatum anterius) (Fig. 148) is quite conspicuous as a strong thick band attached by its lower extremity to the depression in front of the spine of the tibia and

passing upward and outward to acquire connection with the outer condyle on the back part of its inner surface.

The **posterior** or **internal crucial ligament** (lig. cruciatum posterius) (Fig. 148), a similar strong band, has its lower attachment to the depres-

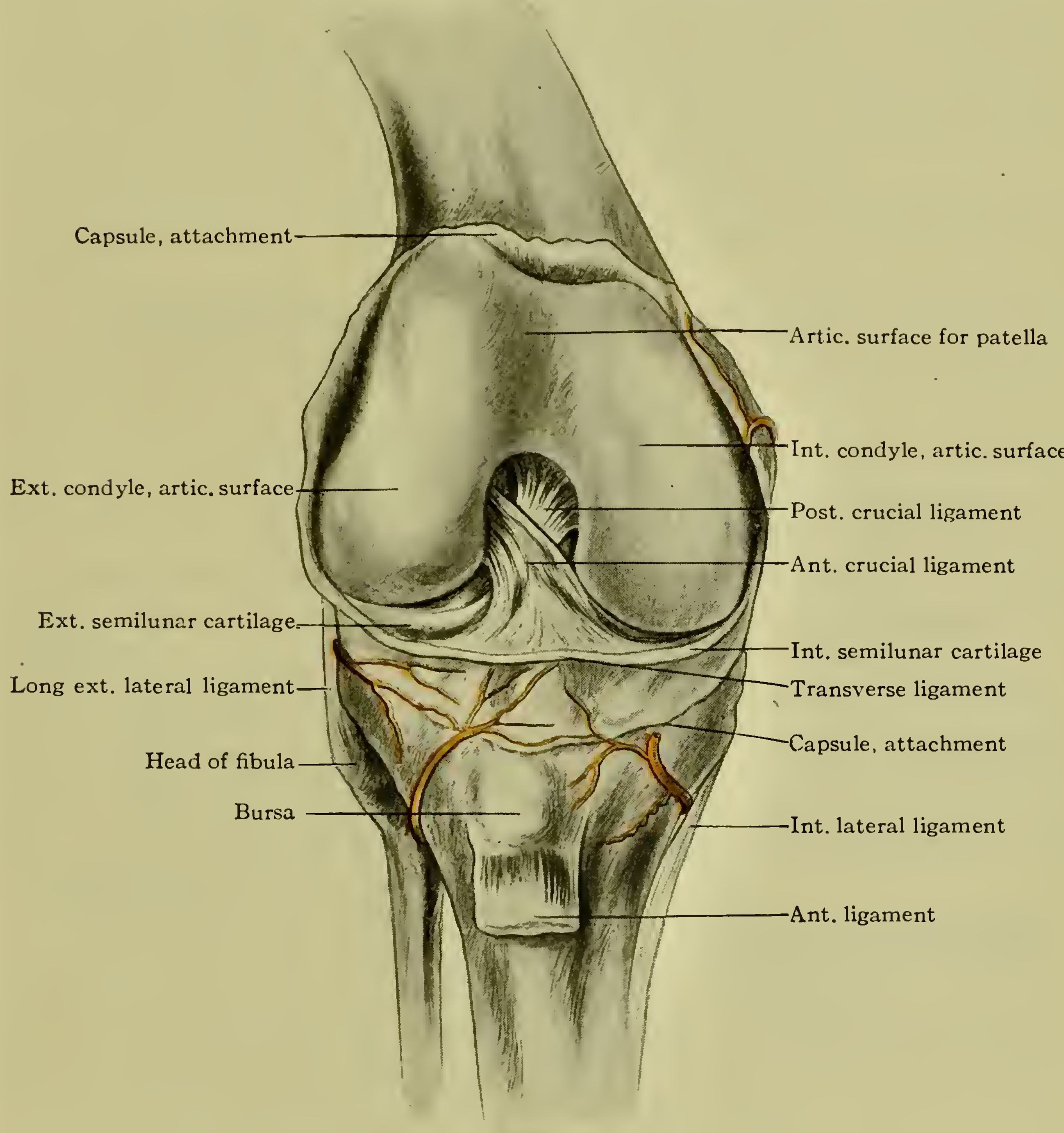

FIG. 148.—The right knee-joint opened in front, the anterior ligament cut and turned downward.

sion behind the spine of the tibia (Fig. 149) and to its popliteal notch, and passing upward and forward is inserted into the inner condyle on the front part of its outer surface.

Once more turning the limb, the posterior ligament should be removed with sufficient care to preserve the azygos articular artery and nerve and to note the loose tissue which is between the posterior liga-

ment and the synovial membrane. A posterior view of the crucial ligaments is thus obtained (Fig. 149). Noting that the posterior crucial ligament is not covered behind with synovial membrane, but is only separated from the posterior part of the capsule by a little areolar

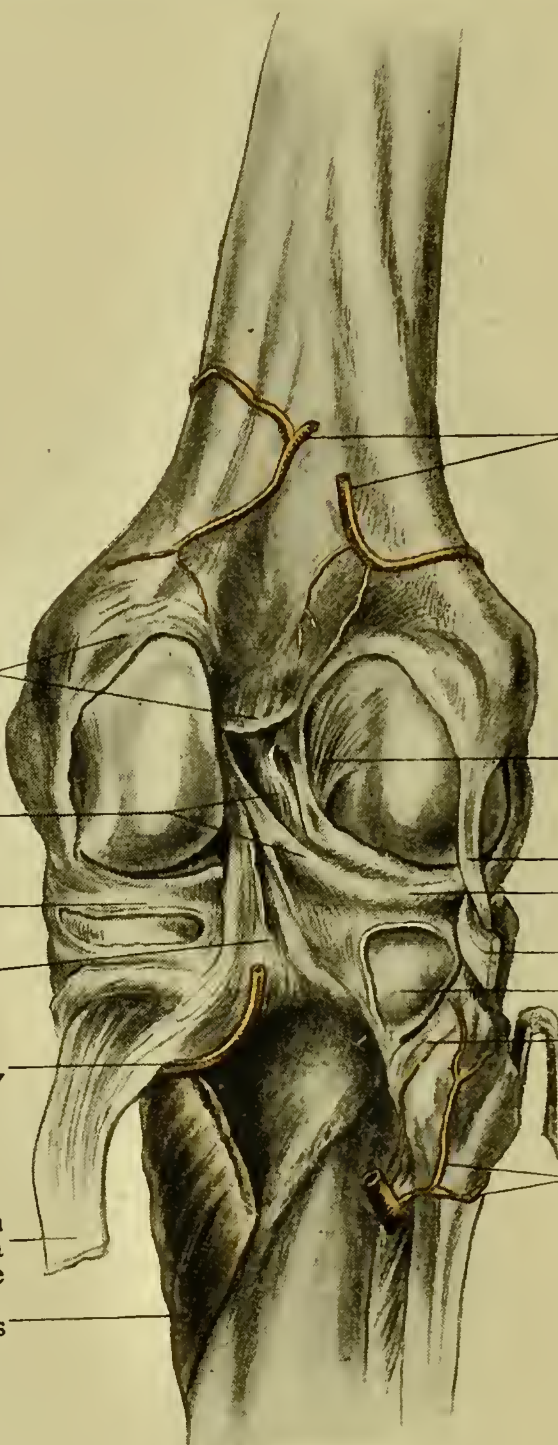

FIG. 149.—The right knee-joint, opened behind.

tissue, the artery and nerve should be traced forward to their terminations in the small branches distributed to the interior of the joint.

The relation of the popliteus tendon to the joint should be noted (Fig. 149), the tendon grooving the posterior surface of the external meniscus and being invested by the synovial membrane. The crucial ligaments constitute strong interosseous ligaments and play an important part in the maintenance of the bones in apposition.

The **synovial membrane,** the most extensive membrane of the kind in the body, lines the capsule and is reflected around the crucial ligaments, not investing, however, the posterior surface of the posterior crucial ligament. As noted above, it covers the deep surface of the large pyramidal mass of fat which is between it and the deep surface of the ligamentum patellæ and here gives origin to the synovial folds referred to above as the ligamentum mucosum and ligamenta alaria. It extends upward upon the thigh a variable distance beneath the quadriceps extensor, the extent to which it does so probably being correlated with the presence and size of the suprapatellar bursa (p. 223).

The **bursæ in relation with the knee-joint** have been indicated in the preceding pages, but may be enumerated here for the sake of completeness.

The **prepatellar bursa** is situated between the patella and the skin (p. 209). There may also be a small *subfascial prepatellar bursa* beneath the deep fascia and a *subtendinous bursa* between the tendon and the patella.

The **suprapatellar bursa** (Fig. 110), one of the most important, is on the front of the femur beneath the quadriceps extensor tendon (p. 223).

The **deep infrapatellar bursa** (Fig. 148) is beneath the lower part of the ligamentum patellæ over the upper portion of the tibial tubercle, and the **subcutaneous tibial bursa** is between the tibial tubercle and the skin.

The **medial bursa of the gastrocnemius,** beneath the inner head of that muscle and pouching between its tendon and that of the semimembranosus (Fig. 134), is important because of its frequent communication with the joint. The less important **lateral bursa** is beneath the outer head of the gastrocnemius and sometimes communicates with the joint (Fig. 147).

Other **bursæ** are found: (1) between the tendon of the biceps and the external lateral ligament (Fig. 147); (2) between the semimembranosus and the head of the tibia; (3) between the semimembranosus and the internal lateral ligament; (4) between the popliteus tendon and the external condyle of the femur, this being usually an extension of the synovial membrane of the joint.

The Movements of the Knee-Joint.—The chief movement of the knee-joint is in the antero-posterior direction, but there is also a slight degree of axial rotation of the tibia. The action of the joint is extremely complex owing to the different shapes and different lengths of the condyles of the femur, to the fact that they are not parallel and to the presence of the slightly elastic and somewhat movable semilunar cartilages.

Inspecting the articular surfaces of the lower end of the femur (Fig. 148) one may note the trochlear surface for articulation with the lower facet of the patella when the leg is in full extension, and the relative

extent of the condylar surfaces which glide over the articular surfaces of the tibia. Because of the shape of these condylar surfaces the antero-posterior movement of the tibia cannot be like that of a true hinge-joint, since the axis about which the tibia moves does not coincide with its points of contact with the femur, but corresponds with a transverse line through a point near the upper and front part of the external condyle. The tibial articular surfaces must therefore glide upon those of the femur in flexion and extension. The difference in length between the outer and the inner condylar surfaces (Fig. 149), and the fact that the fore part of the inner condylar surface inclines outward, bring about that not only does the inner facet of the tibia make a longer excursion in the change from flexion to full extension than the outer facet, but that it passes somewhat forward and outward as the act of extension is completed, a movement which necessarily produces external axial rotation of the tibia. Hence extension of the leg is accompanied by a slight degree of external rotation as a necessary part of full extension, and conversely, when the leg passes from full extension to flexion, the latter movement is initiated by a preliminary internal rotation of the tibia.

The gliding movement of the tibia upon the femoral condyles is recognized in the construction of surgical appliances for the lower limb which are jointed at the knee, the joint of the apparatus not corresponding in location to the interval between the bones, but to a higher point. The student may illustrate this for himself by laying a flat discoid body, such as a silver coin or a small box-lid, upon a plane surface and fastening together by rubber bands two lead-pencils so that the blunt end of one projects beyond the blunt end of the other to an extent equal to half the diameter of the disc employed. If now the blunt end of the shorter pencil be placed against the rim of the coin or box-lid, the blunt end of the longer reaching to its centre, and the two pencils are moved through an arc of forty-five degrees with the centre of the disc as the centre of rotation, the end of the shorter pencil glides upon the rim of the disc. The shorter pencil represents the tibia and the rim of the disc represents the condyles of the femur—but not accurately, since the line of convexity of the condyles is not a part of a circle—while the centre of the disc represents the centre of motion for the tibia.

Attention to the form of the articulating surfaces of the knee-joint would suggest a decided insecurity of the joint against **dislocation.** As a matter of fact dislocation is comparatively rare; the reason for this becomes apparent when one notes the strength of the ligaments, especially of the anterior ligament and of the interosseous ligaments, and the way in which the exterior ligaments are reinforced, the posterior ligament by the aponeurosis of the semimembranosus, the external lateral by the biceps and popliteus tendons, and the internal lateral by the inner hamstring tendons, while the aponeuroses of the vasti help to protect the anterior and lateral aspects of the joint.

The *antero-posterior dislocations*, of which the anterior are the more common, are usually incomplete and are generally the result of indirect violence.

The *backward dislocation*, when complete, is attended with more damage to the structures in the popliteal space than is the anterior form. The deformity in each of the foregoing cases is sufficiently obvious.

The *lateral dislocations* are always incomplete and are produced by force exercised upon the leg in the lateral direction, the thigh being flexed.

Partial displacement (subluxation) of the semilunar cartilages, either in the forward direction or inward or outward, sometimes occurs as the result of forcible rotation of the femur upon the fixed tibia when the leg is in the flexed attitude. The pressure exerted by the femur upon the tibia, combined with the action of either the biceps or the semitendinosus and semimembranosus, approximates the tibial articular surface of one or other side to its femoral condyle, and the cartilage of the other side being released from pressure and at the same time dragged upon, is displaced, its edge being caught between the articular surface of the condyle and that of the tibia.

Disease of the knee-joint is of common occurrence, *tuberculosis*, either acute or chronic, being the most frequent cause. *Synovitis* and *arthritis* also occur from other causes than tuberculosis.

When inflammation of the joint is attended with effusion, the swelling becomes most apparent at the sides of the tendo patellæ and upon the lateral aspect of the joint, the patella itself often being "floated up" by the pressure of the excess of fluid.

The size of the knee-joint and the consequent extent of its synovial membrane, as well as the complicated character of the latter by reason of its being in continuity with so many of the synovial bursæ in relation with the joint, combine to render *infection of this joint*—as by punctured wound, a compound fracture or operative procedure—a condition of particularly serious import.

Various **deformities** are found at the knee, these being due to impairment of the resistance of certain of the ligaments associated with overgrowth of bony tissue. In *genu valgum* or *knock-knee*, the internal lateral ligament yields and elongates, and the inner condyle of the femur and the inner tuberosity of the tibia enlarge, while there is a corresponding atrophy of the outer condyle and tuberosity and shortening of the outer muscular and fascial structures. In *genu varum*, or *extrorsum* or *bow-legs* the external lateral ligament elongates usually as the result of the patient's unwitting efforts to compensate for the backward curvature of the lumbar spine in lumbar rachitis. *Genu recurvatum*, or backward curvature of the knee—the concavity of the curve looking forward—is due to impairment of the crucial ligaments and of the muscles which flex the leg.

The **patella**, owing to its relation to the tendon of the quadriceps extensor, is particularly liable to *fracture* as a result of muscular action combined with leverage. Thus a powerful contraction of the quadriceps when the leg is flexed or semiflexed upon the thigh, as in jumping from a height or in trying to save one's self in the act of falling, may produce this fracture, the lower part of the trochlear surface of the femur serving as the fulcrum, the quadriceps as the power, while the weight is the force which is applied to the lower end of the leg or foot forcing the leg into the flexed position.

The upper fragment of a fractured patella is pulled upward by the quadriceps to a degree that is difficult and usually impossible to overcome except under full anæsthesia and by elevation of the leg and thigh to approximate the po nts of origin and insertion of the muscle; even under these conditions perfect approximation of the fragments is not always possible.

Fibrous union usually occurs in fractured patella due to one or more of several causes which prevent perfect apposition of the fragments, such as the entanglement of shreds of tissue between the fragments of the bone, and the contact of synovial

fluid with the fractured surfaces, the synovial membrane being attached to the deep surface of the patella, and the fracture, if occurring within the limits of its attachment, necessarily opening the joint-cavity.

Dislocation of the patella may occur in either the *outward* or *inward* direction, the outer form being more frequent. The reason seems to be that, on account of the obliquity of the shaft of the femur, the patella is at the apex of an obtuse angle which opens outward, and the contraction of the quadriceps therefore tends to obliterate this angle, and in so doing exercises a pull upon the patella in an outward direction. This lateral pull upon the bone is of course trifling under normal conditions, but in the event of unduly exaggerated action of the muscle may be sufficient to produce the lesion in question. A form of incomplete dislocation also occurs in which the patella is turned upon its edge.

The Tibio-Fibular Articulations.—The tibia and fibula are connected with each other at their extremities and also throughout the greater part of the length of their shafts.

The Superior Tibio-Fibular Articulation.—The **articular surfaces** of this **arthrodial** joint are the facet on the under surface of the outer tuberosity of the tibia and the facet on the head of the fibula. The **ligaments** are the *capsular*, and the *anterior* and the *posterior superior tibio-fibular ligaments* (lig. capituli fibulæ) (Fig. 147).

The **capsular ligament** is stronger in front than behind and is strengthened by the anterior and posterior ligaments. The **anterior ligament** is directed downward and outward from the front of the outer tibial tuberosity to the head of the fibula. The **posterior ligament** passes downward and outward from the back part of the outer tibial tuberosity to the head of the fibula.

The **synovial membrane** of the joint is sometimes continuous with that of the knee-joint.

The **middle tibio-fibular articulation** comprises simply the connection of the interosseous borders of the two bones by the thin laminar **interosseous membrane** (membrana interossea cruris), which consists of fibres directed chiefly downward and outward, but includes fibres which pass in the opposite direction. The interosseous membrane is perforated near its lower end by the anterior peroneal artery and is continuous with the inferior interosseous ligament. It ends above in a free concave border, above which pass the anterior tibial vessels. Its front surface is in relation with the anterior tibial group of muscles and the anterior tibial vessels and nerve; its posterior surface is in relation with the tibialis anticus and the flexor longus hallucis.

The Inferior Tibio-Fibular Articulation (syndesmosis tibiofibularis).—The **surfaces** concerned in this joint, which is an **arthrodial** joint of limited capacity, are the outer rough surface of the lower end of the tibia and the similar rough surface on the inner aspect of the lower extremity of the fibula, only the lower portions of these surfaces being coated with cartilage. The **ligaments** are the *anterior* and *posterior inferior tibio-fibular*, the *transverse* and the *interosseous*.

The **anterior inferior tibio-fibular ligament** (lig. malleoli lateralis anterius) (Fig. 153) extends obliquely downward and outward from the front of the tibia to the front of the outer malleolus of the fibula. The **posterior inferior tibio-fibular ligament** (lig. malleoli lateralis posterius) is similarly placed and attached posteriorly (Fig. 152).

The **transverse** or **inferior ligament** (Fig. 154) is a strong, thick band passing from the back part of the outer malleolus to the entire length of the posterior border of the inferior articular surface of the tibia. Projecting below the margin of the tibia, it helps to form the articular cavity of the ankle-joint and comes into relation with the astragalus.

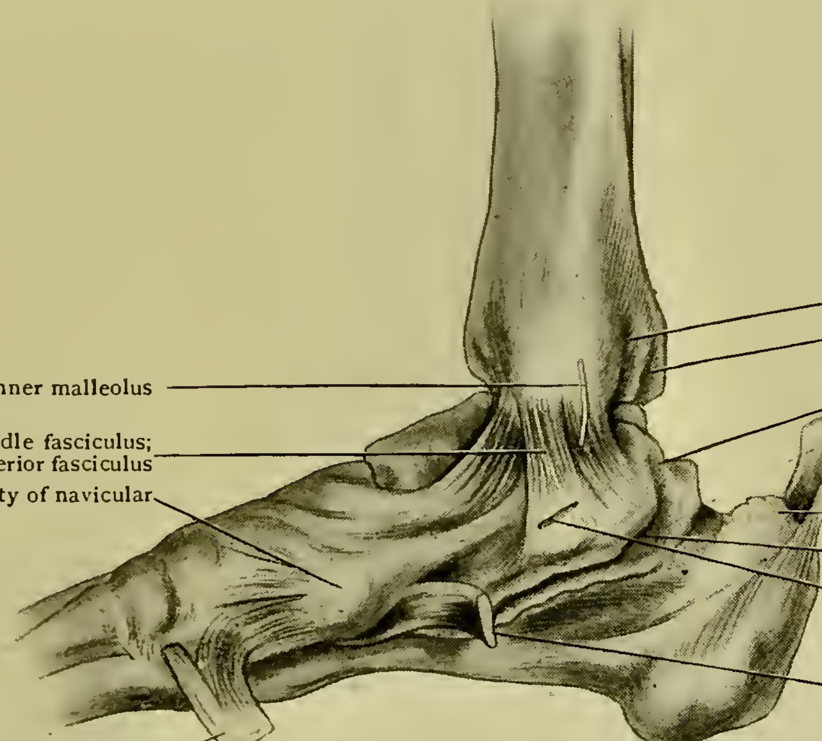

FIG. 150.—The right ankle-joint, inner aspect.

The **inferior interosseous ligament** (Fig. 154), continuous above with the interosseous membrane, connects the opposed surfaces of the tibia and fibula. It consists of strong fibrous bands and is the chief factor in the maintenance of the apposition of the bones.

The **synovial membrane** of this joint is a part of that of the ankle-joint.

THE ANKLE-JOINT.—The **articular surfaces** concerned in this **gingly-mus joint** are those of the tibia and fibula and of the astragalus, the outer facet of the astragalus articulating with the malleolar facet of the fibula, its inner facet with the inner malleolus, and its upper surface with the inferior surface of the tibia.

The **ligaments** are the *internal lateral* or *deltoid ligament*, the *external lateral*, the *anterior tibio-tarsal*, and the *posterior tibio-tarsal ligaments*, which collectively constitute a *capsule*.

The **blood-supply** of the joint is from the malleolar branches of the anterior tibial, the external calcanean branches of the peroneal and usually from the posterior tibial by a branch which enters the joint on its inner aspect.

The **nerve-supply** is from the anterior and posterior tibial nerves (Figs. 150 and 153) and the external saphenous (Fig. 151).

The **movements** are flexion and extension.

The **internal lateral** or **deltoid ligament** (lig. calcaneotibiale) is attached above to the tip and borders of the inner malleolus and separates into three bands, the *anterior band* passing downward and forward

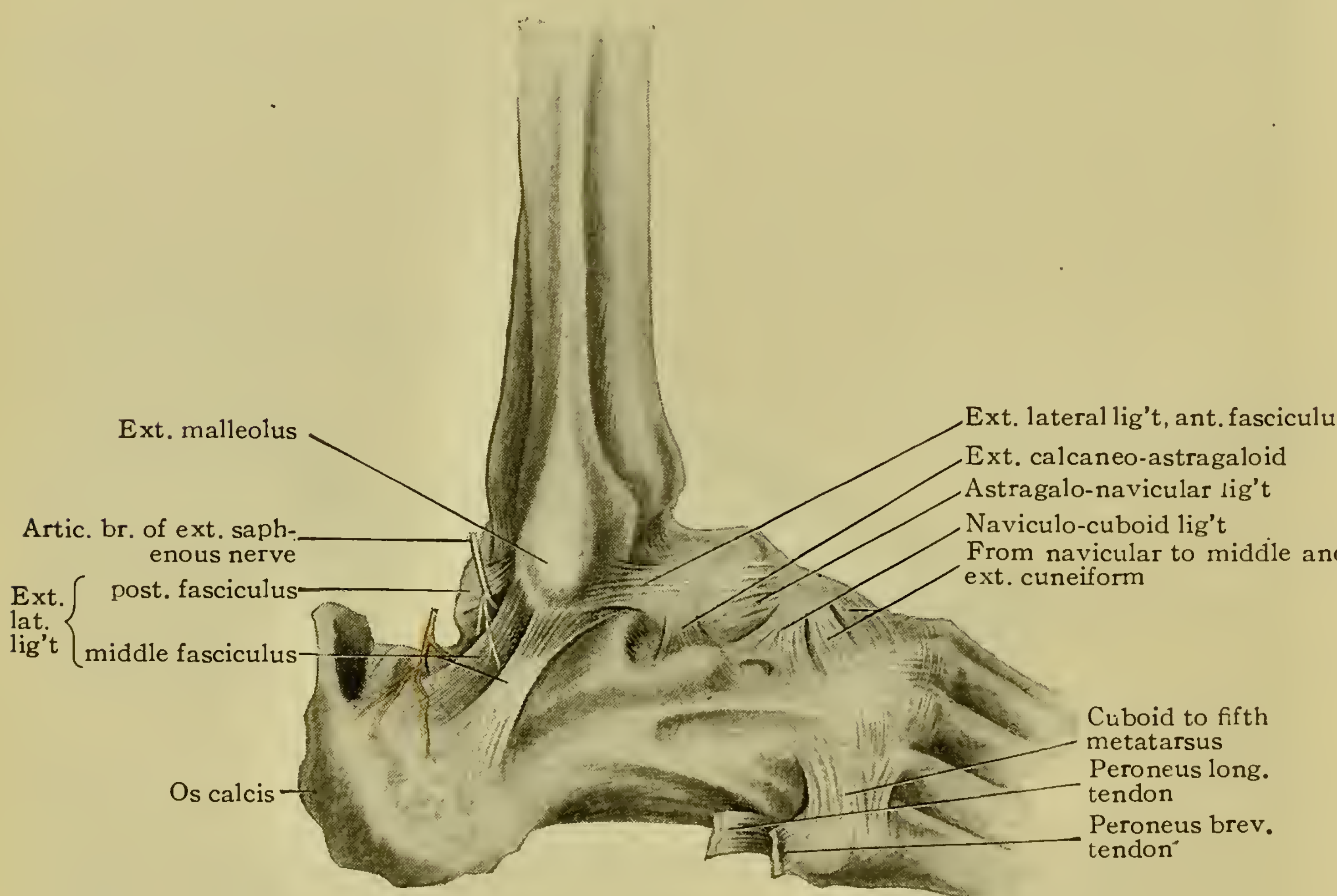

FIG. 151.—Right ankle-joint, outer aspect.

to be attached to the navicular bone and the inferior calcaneo-navicular ligament, while the *middle fasciculus* passes downward to be attached to the sustentaculum tali, its deep fibres acquiring connection with the astragalus, and the *posterior band* is directed downward and backward to become connected with the astragalus. To expose this ligament the tendons and the vessels and nerves behind the inner malleolus (Fig. 138) must be removed, note being taken of the articular branches of the posterior tibial nerve and articular branches of the anterior and posterior tibial arteries which perforate it. Denuding its surface the three fasciculi will be evident; the strength of these bands is noteworthy (Fig. 150).

The **external lateral ligament** (Fig. 151), attached above to the outer malleolus, divides into three bands, the *anterior band* passing almost horizontally forward and inward to be attached to the astragalus (Fig. 151), the *middle band* going downward and backward to attach to the os calcis, while the *posterior fasciculus* is directed almost horizontally inward and backward to its attachment to the astragalus,

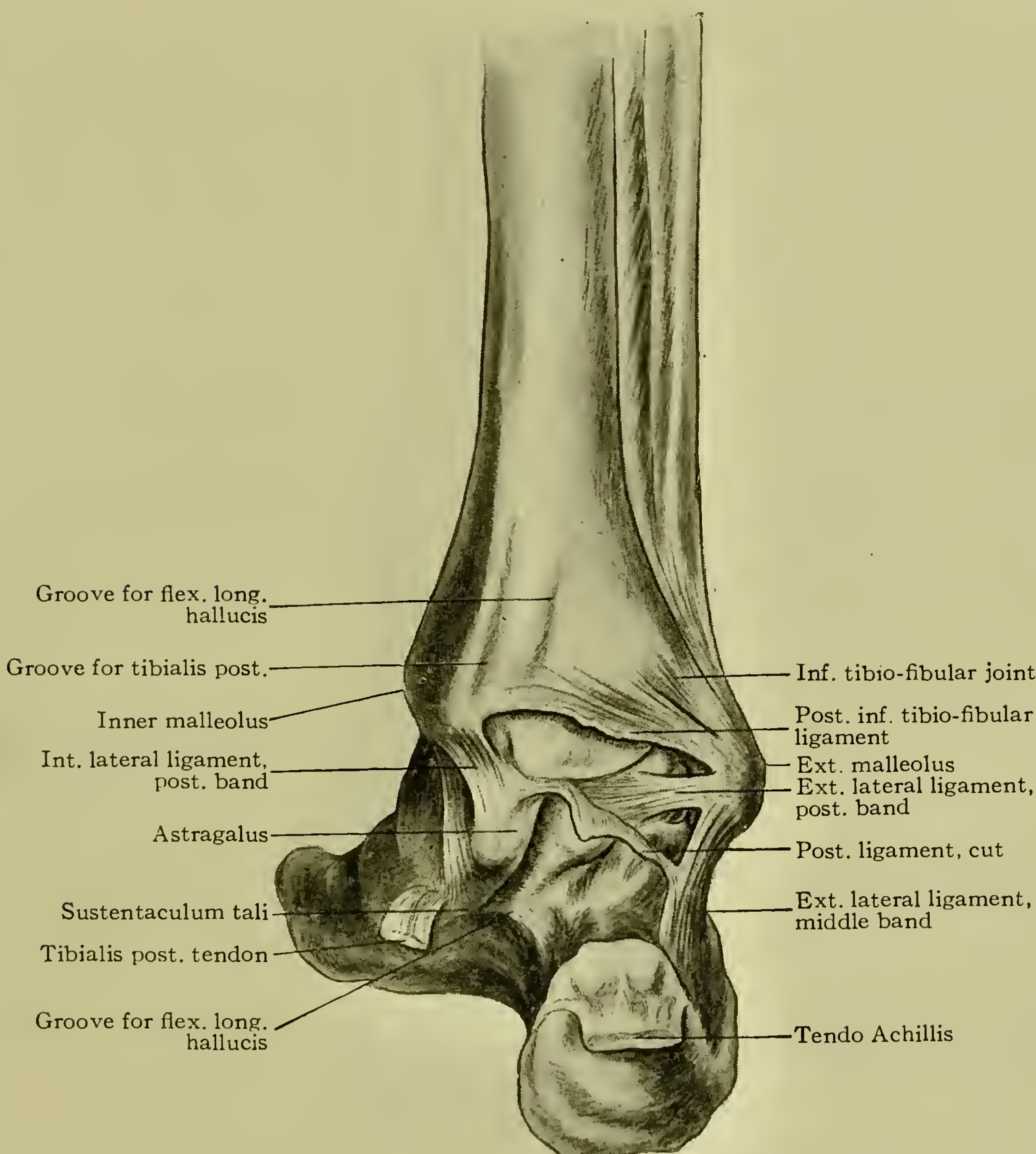

FIG. 152.—Right ankle-joint, posterior aspect; the posterior part of the capsule has been cut.

serving to strengthen the posterior ligament. To expose this ligament, the tendons of the peronei longus and brevis should be divided below and removed. Pulling the external saphenous nerve outward, the articular branches of this nerve will be seen entering the capsule. If the foot be flexed, the posterior band of the ligament becomes tense, while in extension of the foot the anterior band is seen to tighten.

The **posterior ligament** (Fig. 152) is very thin; it is attached above to the margin of the articular surface of the tibia and below to the back of the astragalus. The tendons, including the tendo Achillis, and the mass of fat found here must be removed to expose this ligament.

The **anterior ligament** (Fig. 153) is attached above to the lower margin of the tibia and below to the astragalus. Clearing away the

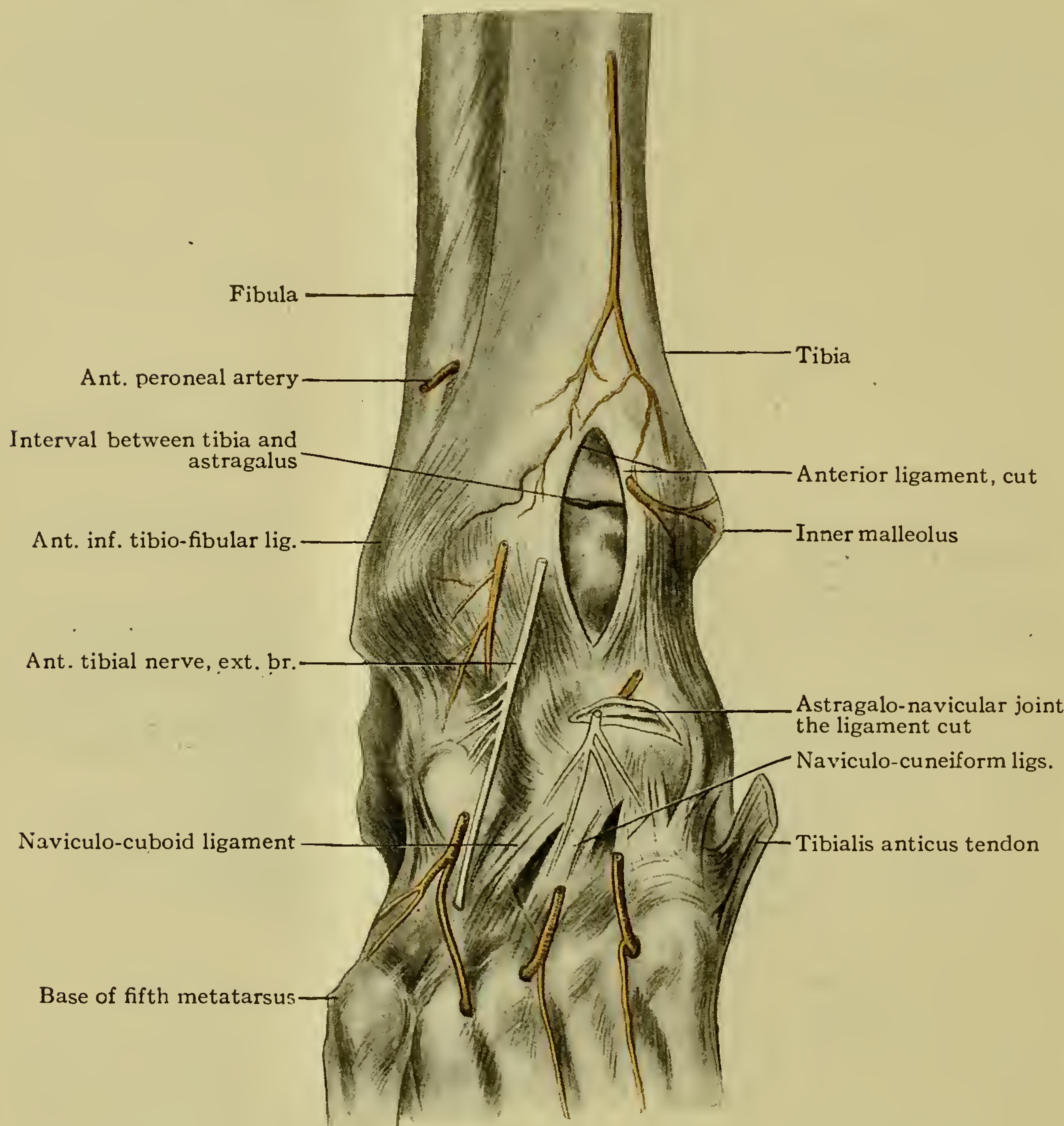

Fig. 153.—Right ankle-joint, anterior aspect; the anterior ligament has been incised.

tendons in relation with the front of the joint—the articular branch of the anterior tibial nerve and the articular branches of the malleolar arteries being identified—this ligament is exposed. After noting its attachments it may be incised (Fig. 153) to expose the interior of the joint. When the joint is opened still further at a later stage of the

work (p. 308) the **synovial membrane** will be seen to extend upward between the tibia and fibula (Fig. 154).

The **relations** of the ankle-joint have been made sufficiently obvious in the removal of the various structures in relation with its respective aspects (vide supra, pp. 254, 256 and 270).

The ankle-joint is notably liable to *sprain*, a form of injury which usually results in synovitis. Swelling in case of *effusion* into the joint is most apparent on the anterior and posterior aspects because of the relative weakness of the anterior and posterior ligaments.

Owing to the conformation of the articular surfaces (Fig. 154), **dislocations** of this joint are not very frequent. Dislocations occur, however, in both the antero-posterior and lateral directions. The *lateral dislocations* are the more common and are almost invariably and of necessity associated with fracture of either the tibia or fibula and a partial rotation of the astragalus about an antero-posterior axis drawn through its centre, so that its superior surface, instead of looking directly upward, inclines to one side, the side opposite that toward which the bone is displaced.

The Articulations of the Foot.—In the dissection of the joints of the foot, it will be advantageous to begin the work without too much regard for the individual articulations, deferring consideration of these for the present, since the complete dissection of any one joint interferes to an undesirable degree with the relations of others and with the consideration of the foot as a whole. First note the relations of the tarsal bones to each other and to the metatarsus as indicated above (p. 248), as also the antero-posterior arch and the smaller transverse arch constituted by these bones, that the special functional importance of certain of the ligaments may be appreciated.

The Dorsal Ligaments of the Tarsus.—Clearing away all remnants of tendons and any cellular tissue that may remain, these ligaments may be dissected in the order indicated below.

The **superior astragalo-scaphoid** or **astragalo-navicular ligament** (Fig. 151) is seen as a fibrous band connecting the contiguous dorsal, and to some extent the inner, surfaces of the astragalus and scaphoid bones, while radiating from the scaphoid bone are the **dorsal scapho-cuboid ligament,** which passes to the dorsal surface of the cuboid, and the **dorsal scapho-cuneiform ligaments** (Fig. 153), the latter appearing as if continuations of the astragalo-scaphoid ligament and passing respectively to the internal, the middle and the external cuneiform bones.

The **external scapho-cuneiform ligament** is closely related with the dorsal cuneo-cuboid ligament, which connects the dorsal surfaces of the external cuneiform and cuboid bones (Fig. 151). In close association with these are the two **dorsal cuneiform ligaments,** connecting the dorsal surfaces of the three cuneiform bones.

The **superior** or **external calcaneo-scaphoid ligament** (Fig. 157), which connects the anterior part of the dorsal surface of the calcaneum with the scaphoid bone, is seen in the hollow below and to the outer

side of the head of the astragalus while the dorsal **calcaneo=cuboid ligament** (Fig. 151) presents as a flat band connecting the contiguous parts of the calcaneum and cuboid bones.

The **dorsal tarso=metatarsal ligaments** (Fig. 151) are conspicuous as strong flat bands connecting the dorsal surfaces of the three cuneiform and cuboid bones with the bases of the metatarsi.

The Plantar Ligaments of the Foot.—On the plantar surface one of the most conspicuous ligaments is the **long calcaneo=cuboid ligament**

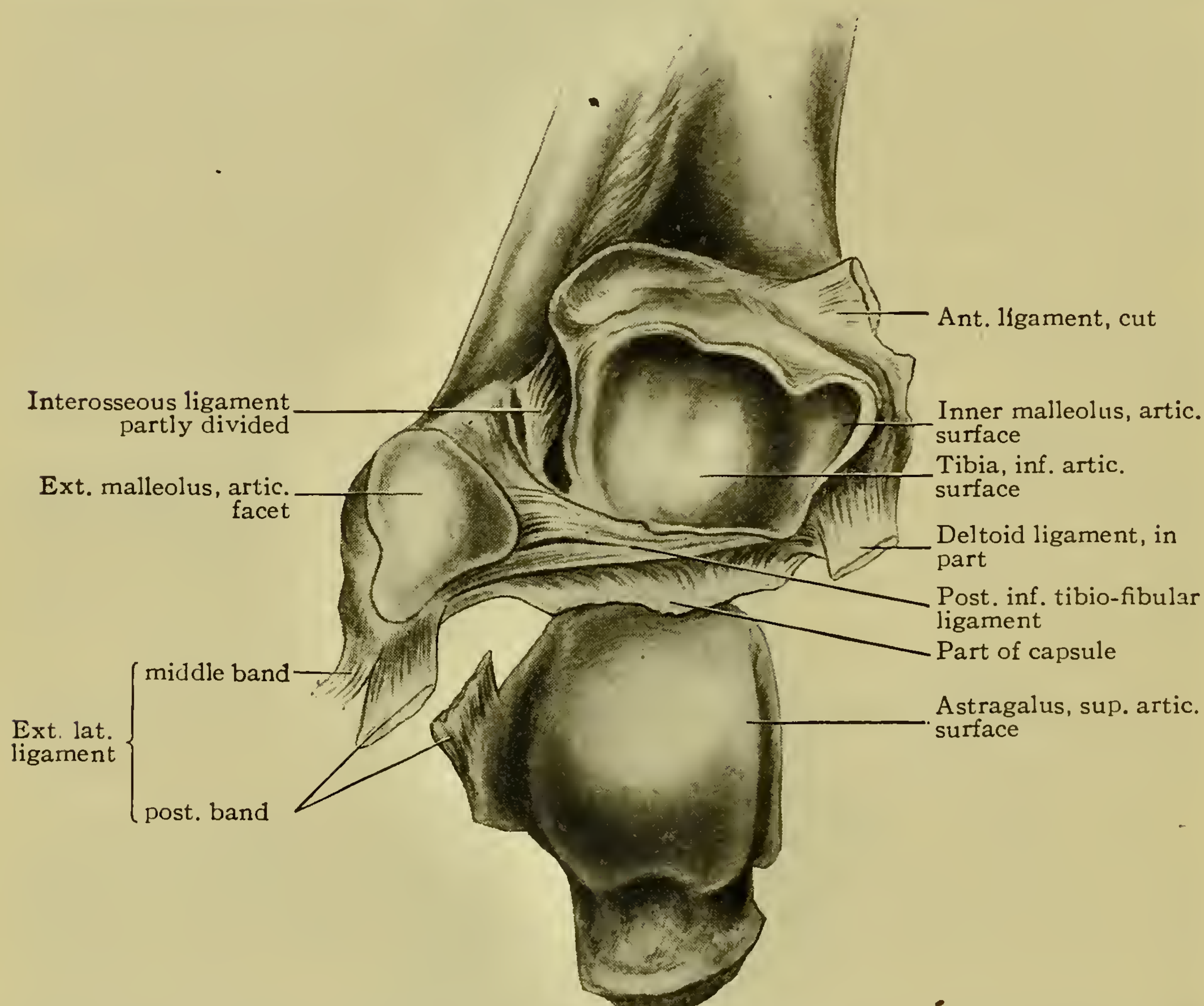

Fig. 154.—The articular surfaces of the ankle-joint; the anterior part of the astragalus has been displaced downward, after severing most of its attachments.

attaching behind to the under surface of the os calcis or calcaneum in front of the tubercles, and in front to the under surface of the cuboid including its ridge, the more superficial fibres continuing forward to blend with the cubo-metatarsal ligaments and in doing so forming the aponeurotic canal for the peroneus longus tendon (Fig. 155). This has been demonstrated (page 288). Reflection backward of the long calcaneo-cuboid ligament discloses the **short calcaneo=cuboid ligament,** the attachments of which are the under surface of the calcaneum and the under surface of the cuboid behind the peroneal groove (Fig. 156).

The **aponeurotic expansions** derived from the tendon of the tibialis posticus at its insertion into the navicular and internal cuneiform bones should be cleaned and examined. One such expansion passes backward to the sustentaculum tali (Fig. 155), another goes forward and outward to the cuboid and the outer and middle cuneiform bones, and another to the bases of the second, third and fourth metatarsi.

The inferior surface of the **inferior calcaneo-scaphoid ligament,** the so-called " spring ligament " (Fig. 156), should be cleaned and examined.

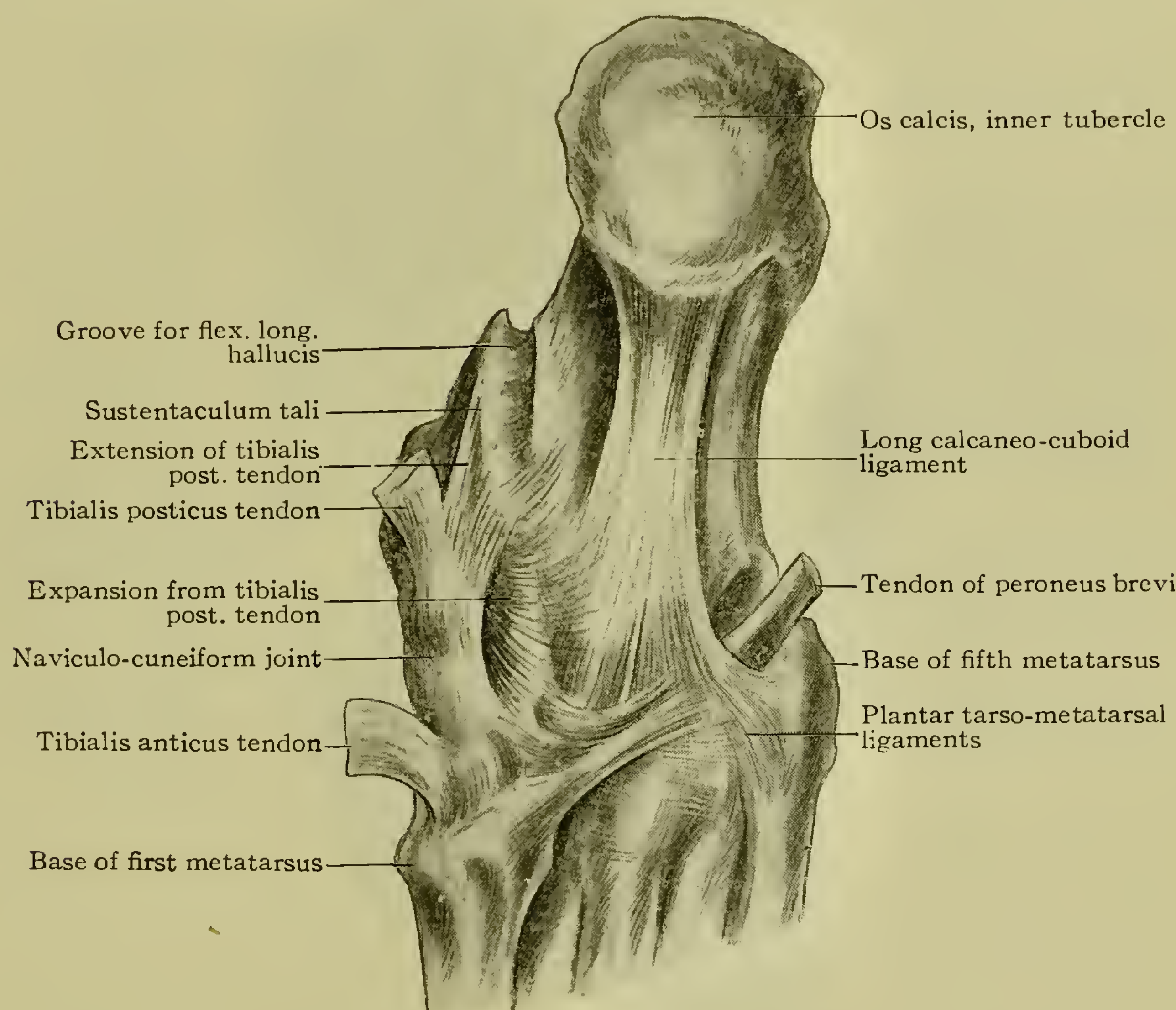

FIG. 155.—The plantar ligaments of the tarsus.

Placing the sole of the foot on the table, it will be seen that this ligament bears an important relation to the antero-posterior arch of the foot, connecting as it does the calcaneum and the scaphoid, the limbs of the arch, and receiving on its upper surface the pressure exerted by the head of the astragalus, with the under surface of which it is in contact and which might be looked upon as the keystone of the arch.

The Movements of the Foot.—It will be well to consider the movements of the foot at this stage of the work, since the complete dissection of the joints involves the disarticulation of the bones. The movements of extension and dorsal flexion of the foot occur at the ankle-joint where

also a slight degree of lateral motion is permitted when the foot is in full extension, since in this position the narrow posterior part of the upper articular surface of the astragalus is brought forward into the widest part of the tibio-fibular mortise. Inversion and eversion of the foot, which are usually combined respectively with adduction and abduction, in so far as these movements are effected without rotation of the femur, are brought about largely by the movements of the

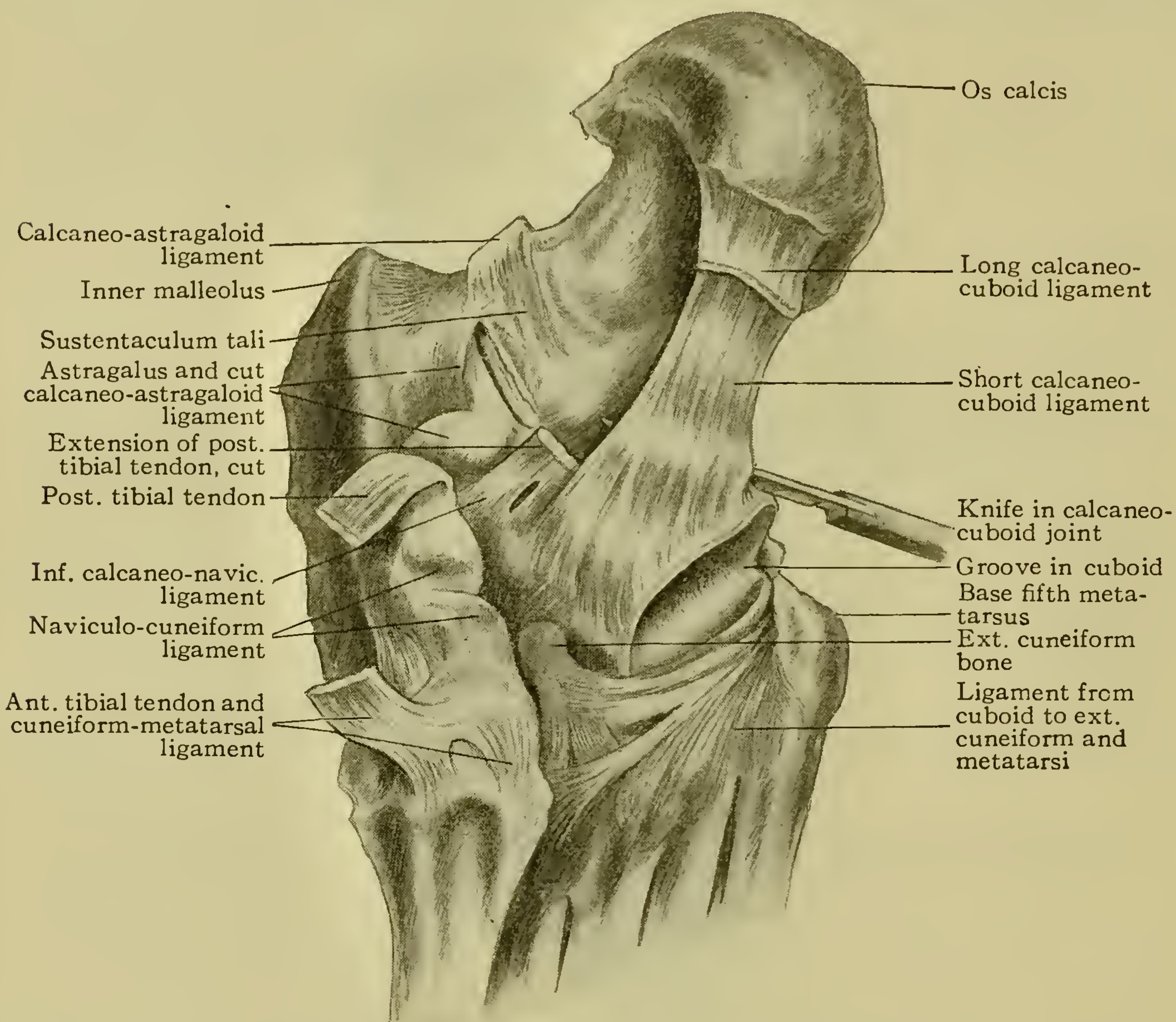

FIG. 156.—The plantar ligaments of the tarsus, the long calcaneo-cuboid ligament cut.

calcaneo-astragaloid joints but also by the motion of the mid-tarsal joint, the motion at these joints being supplemented by the slight gliding movements of the other tarsal joints.

THE CALCANEO-CUBOID ARTICULATION. — The **articular surfaces** involved in this joint, which is of the **arthrodial** type, are the anterior surface of the os calcis and the posterior surface of the cuboid. The **ligaments** are the *long* or *superficial calcaneo-cuboid* or *long plantar ligament*, the *short* or *deep calcaneo-cuboid* or *short plantar ligament*, the *dorsal* or *superior calcaneo-cuboid ligament* on the superior aspect of the

joint and the *interosseous ligament*. These ligaments have already been dissected except the last named; their attachments are noted on pages 303 and 304.

The internal or interosseous ligament arises in common with the superior calcaneo-scaphoid ligament from the upper anterior part of

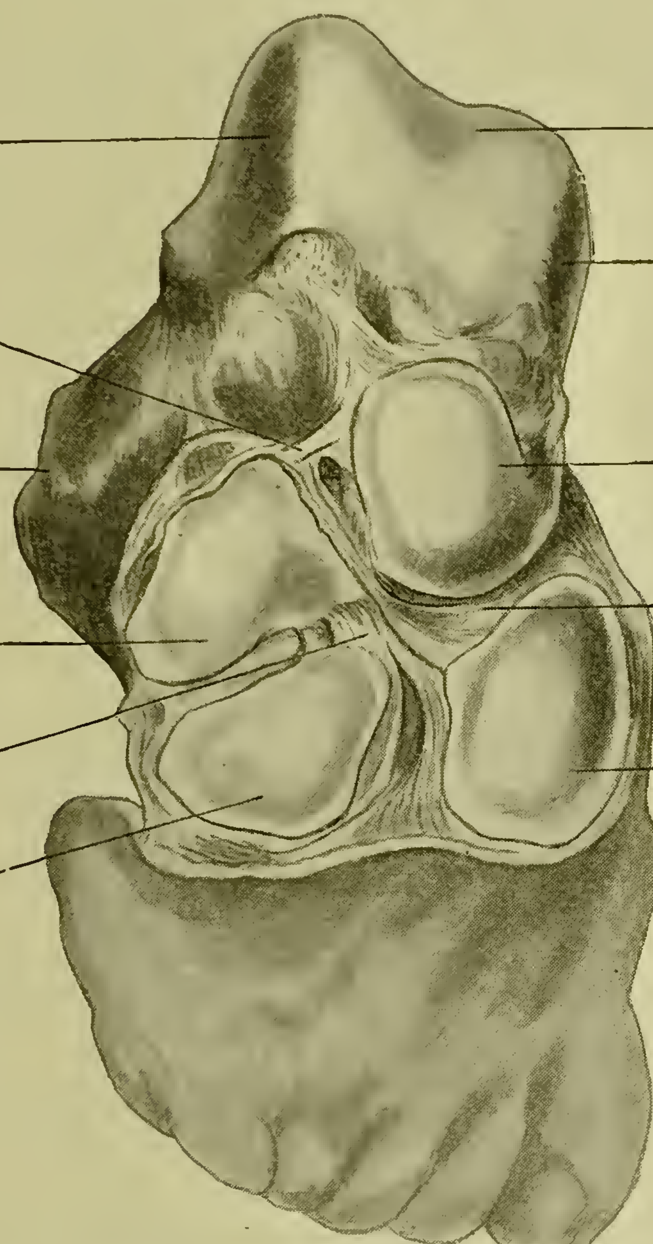

FIG. 157.—The medio-tarsal joint; the dorsal ligaments have been cut and the anterior part of the foot sharply flexed.

the os calcis (vide p. 303) and is inserted into the inner side of the cuboid bone.

THE ASTRAGALO-SCAPHOID ARTICULATION.—The **articular surfaces** concerned here are the head of the astragalus and the concave posterior articular facet of the scaphoid, the latter being supplemented by the upper surface of the inferior calcaneo-scaphoid ligament and the anterior part of the upper surface of the os calcis. The only **ligament** is the *superior* or *dorsal astragalo-scaphoid* (p. 303), the place of an inferior ligament being supplied by the inferior calcaneo-scaphoid ligament.

These two joints constitute what is known as the **transverse** or **mid-tarsal** or **medio-tarsal joint,** which, as mentioned above, plays an important part in the lateral movements of the foot.

The dorsal ligaments of these two joints may now be incised and the anterior part of the foot sharply flexed, as shown in Fig. 157, that the articular surfaces of the bones may be examined.

Amputation through the line of the medio-tarsal joint is known as Chopart's amputation.

THE CALCANEO-ASTRAGALOID ARTICULATIONS. — The **articular surfaces** involved in these articulations are the two or sometimes three articular facets on the under surface of the astragalus and the two or sometimes three corresponding facets on the upper surface of the os calcis, one of which, sometimes divided into two, is found on the lesser process or sustentaculum tali. The **ligaments** are the *anterior*, the *posterior*, the *internal*, and the *external calcaneo-astragaloid* (ligg. talocalcaneum anterius, posterius, mediale et laterale) and the *interosseous*.

The **external calcaneo-astragaloid ligament** is a strong band which connects the outer surface of the astragalus just below its articular facet with the adjacent part of the os calcis. It is placed in front of the middle fasciculus of the external lateral ligament of the ankle (Fig. 151).

The **internal calcaneo-astragaloid ligament** passes from the tubercle at the inner back part of the astragalus to the back of the sustentaculum tali.

The **anterior ligament** connects the antero-external part of the neck of the astragalus with the upper surface of the os calcis.

The **posterior ligament** passes from the outer tubercle at the back of the astragalus to the upper part of the os calcis.

The **interosseous ligament** is to be exposed by separating the astragalus from the os calcis after having divided the foregoing ligaments as well as the internal lateral ligament of the ankle-joint and the middle and anterior bands of the external lateral ligament, and at least a part of the interosseous ligament itself, which is the strongest bond of union between the bones. Having separated the bones as shown in Fig. 158, the attachments of the interosseous ligament will be seen to be the rough groove in each case between the articular surfaces of the bones.

The **synovial membranes** include one for the posterior articulation and one for the anterior, the latter being continuous with that of the astragalo-scaphoid articulation.

The **movements** of the calcaneo-astragaloid joints are such as permit of inversion and adduction and eversion and abduction of the foot, the line of motion of the os calcis in the case of each joint being along the long axes of the respective surfaces and extending therefore from behind obliquely forward and outward.

THE CALCANEO-SCAPHOID ARTICULATION.—These bones, which do not articulate directly, are brought into relation with each other by the *inferior* or *internal calcaneo-scaphoid ligament* and the *superior* or *external calcaneo-scaphoid ligament.*

The **superior** or **external ligament** is attached behind to the upper part of the anterior surface of the os calcis in connection with the internal calcaneo-cuboid ligament—these two being sometimes regarded as a single ligament, the *ligamentum bifurcatum,* which separates into two parts as it passes forward, the external calcaneo-scaphoid and the internal calcaneo-cuboid—and in front to the outer side of the scaphoid bone (Fig. 157).

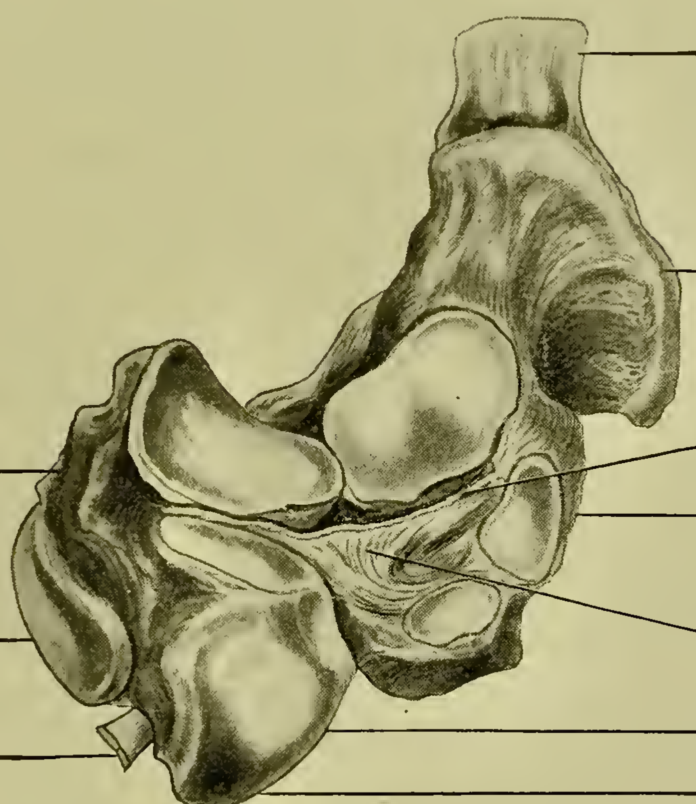

FIG. 158.—Dissection showing interior of calcaneo-astragaloid articulations of right foot. The astragalus is turned outward.

The **inferior** or **internal calcaneo-scaphoid ligament** is attached behind to the anterior margin of the sustentaculum tali and in front to the under surface of the scaphoid. Its importance in helping to form the articular cavity for the head of the astragalus has been noted (p. 305).

THE SCAPHO-CUNEIFORM ARTICULATIONS (articulatio cuneonavicularis).—These are effected by the three articular facets on the anterior aspect of the scaphoid which articulate with the posterior surfaces of the three cuneiform bones. (*Vide* page 303.)

The movement is limited to a slight gliding of the bones upon each other.

THE INTERCUNEIFORM ARTICULATIONS.—The three cuneiform bones are articulated with each other by two joints each of which is formed by the opposed articular facets, the bones being held together by *dorsal,*

plantar and *interosseous ligaments*. The **dorsal** and **plantar ligaments** have been sufficiently considered (p. 303). The **interosseous ligaments,** upon separation of the bones, will be found to connect the opposed surfaces of the inner and middle and those of the middle and external cuneiform bones.

The **synovial membrane** is a part of the great tarsal membrane.

The movements of these joints are limited to a slight gliding of the bones upon each other.

THE CUNEO-CUBOID ARTICULATION. — The outer surface of the external cuneiform is articulated with the inner surface of the cuboid through the medium of the **dorsal** and **plantar ligaments**—which have been noted (p. 303)—and the **interosseous ligament** which connects the non-articular portions of the opposed surfaces of the bones. The latter should now be examined.

The **synovial membrane** is a part of the great tarsal sac and the movement consists of slight gliding.

THE CUBO-SCAPHOID ARTICULATION.—There is usually no articular facet on either the cuboid or the navicular for articulation with each other; when such facets exist, the facet of the cuboid is on the upper back part of its inner surface and that of the navicular is on the corresponding part of its outer surface. The **ligaments** are the *dorsal* (p. 303 and Fig. 151), the *plantar*, and the *interosseous*, the last named connecting the non-articular portions of the opposed surfaces.

THE TARSO-METATARSAL ARTICULATIONS.—The **articular surfaces** concerned in these **arthrodial** joints are those upon or near the distal aspects of the cuboid and the three cuneiform bones and those on the bases of the metatarsi. The **ligaments** are the *dorsal*, which have been sufficiently considered (p. 304 and Fig. 151), the *plantar* and the *interosseous*. The **plantar tarso-metatarsal ligaments** consist of rather irregular bands which connect the surfaces of the bones concerned (Fig. 155).

The **interosseous ligaments** include: the *internal*, which connects the front part of the outer surface of the internal cuneiform with the opposed inner facet on the base of the second metatarsus (Fig. 126); the *middle*, which connects the external cuneiform with the contiguous angle of the base of the second metatarsus; the *external*, which unites the outer angle of the external cuneiform with the base of the third metatarsus. These ligaments should now be exposed by separating the corresponding bones.

It should be noted that the base of the first metatarsus articulates with the internal cuneiform; that of the second metatarsus, with all three cuneiforms, being wedged between the outer and inner and being therefore very strongly jointed with the tarsus—a fact probably related to its being the longest of the metatarsal bones, its head extending farthest forward and therefore bearing a considerable share of the pressure upon the anterior limb of the arch of the foot; that the third meta-

tarsus articulates with the external cuneiform, the fourth with the external cuneiform and the cuboid, and the fifth with the cuboid.

The **synovial membrane** of the joint between the first metatarsus and internal cuneiform and that between the fourth and fifth metatarsi and the cuboid are, in each case, isolated sacs; the synovial sacs of all the other tarso-metatarsal joints are parts of the common tarsal synovial membrane.

The Intermetatarsal Articulations.—The joints between the *bases* of the metatarsi, which are **arthrodial** and permit of but slight motion, present **dorsal** (Fig. 151) and **plantar** (Fig. 155) **ligaments,** which are transverse bands more or less intimately blended with the dorsal and plantar tarso-metatarsal ligaments; and **interosseous ligaments** which connect the non-articular areas of the opposed surfaces with each other, except in the case of the first and second metatarsal bones.

The **synovial membrane** between the second and third and the third and fourth bones is a part of the common synovial sac of the tarsus, while that between the fourth and fifth bones is an extension from the cubo-metatarsal sac.

The *distal extremities* of the metatarsi are connected by the **transverse metatarsal ligament,** which blends in front with the plantar ligaments of the metatarso-phalangeal joints and is related by its deep surface with the interossei tendons and by its superficial aspect with the flexor tendons.

The **nerve-supply** of the tarsal and of the tarso-metatarsal joints is from the anterior tibial nerve chiefly, a few twigs being contributed by the deep branch of the external plantar nerve.

The **synovial membranes** of the tarsus and metatarsus include: (1) one for the posterior calcaneo-astragaloid joint; (2) one for the anterior calcaneo-astragaloid and the astragalo-scaphoid joints; (3) one for the calcaneo-cuboid joint; (4) one for the joint between the internal cuneiform and the first metatarsus; (5) one for the joint between the cuboid and the fourth and fifth metatarsi; (6) a large sac for the scapho-cuneiform, the intercuneiform, the cubo-cuneiform joints, the joints formed by the middle and external cuneiform bones with the second and third metatarsi, and the joints between the bases of the second and third and the third and fourth metatarsi; (7) a sac which is sometimes found between the scaphoid and the cuboid.

The Metatarso-Phalangeal Articulations.—The elements of these condyloid joints are the rounded heads of the metatarsi and the concave facets of the proximal ends of the proximal phalanges. The **ligaments** are the *plantar*, the *lateral* and the *capsular*, the place of a posterior ligament being supplied by the aponeurosis of the extensor tendon.

The **plantar** or **glenoid ligaments** (ligg. accessoria plantaria), thick and strong and continuous with the lateral ligaments, are grooved for the

flexor tendons—except in the case of the great toe—and are connected with their sheaths and with the transverse metatarsal ligament. Two sesamoid bones are found in the plantar ligament of the great toe, the deep surfaces of which are covered with synovial membrane (Fig. 159).

The **lateral ligaments** (ligg. collateralia) are strong bands attached, each one, to the tubercle beside the head of the metatarsus and, distally, to the adjacent part of the proximal phalanx.

The movements of these joints are flexion, extension, adduction, and abduction.

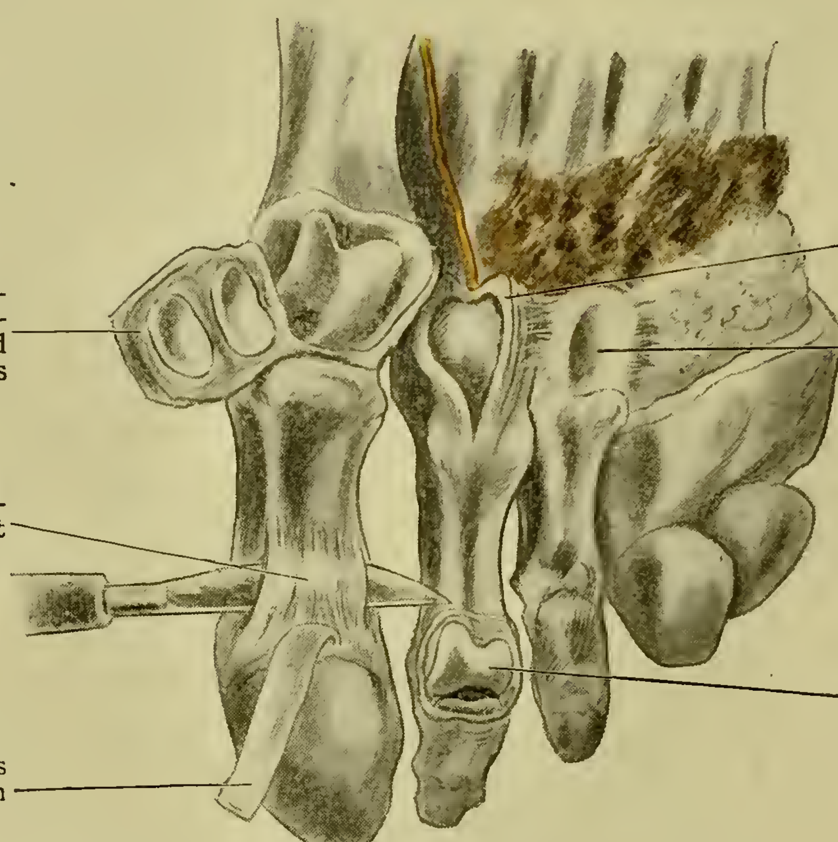

Fig. 159.—Metatarso-phalangeal and interphalangeal joints of right foot, plantar surface.

The Interphalangeal Articulations.—The account of the corresponding joints of the upper extremity (p. 158) will apply to these joints if the word *plantar* be substituted for *palmar* or *volar*.

The bones of the foot are not especially liable to **fracture,** this relative immunity being probably due to the foot's being composed of a number of elements—the individual bones—related to each other by more or less yielding joints and strong ligaments. Fractures from direct violence are apt to be extensively comminuted. The **calcaneum** is subject to fracture from indirect violence and by muscular action in its posterior part; the displacing effect of the gastrocnemius and soleus in such case has been mentioned (p. 261). Its *sustentaculum tali* may also be fractured. The **astragalus** is sometimes fractured and usually at its weakest part, the neck.

Dislocation of the tarsal bones occasionally occurs. Dislocation of the astragalus —the bone most commonly luxated—from the tibia and fibula has been noted (p. 303). *Subastragaloid luxation*, the other bones being dislocated from the astragalus, which retains its relation to the tibia and fibula, may occur, as may also a dislocation of the astragalus from all its connections.

CHAPTER III

THE HEAD AND NECK

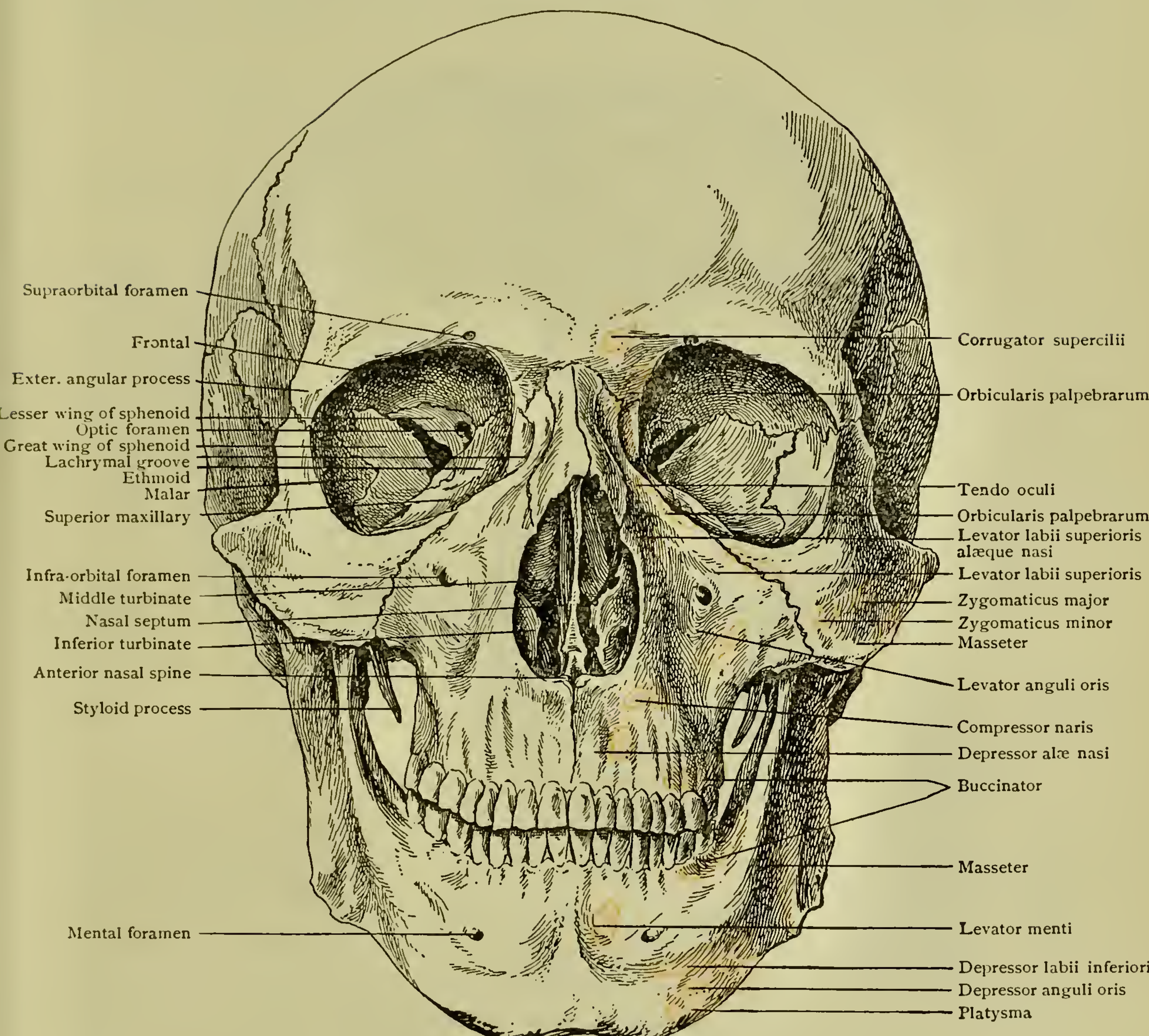

FIG. 160.—Anterior aspect of skull.

THE SCALP.

REVIEWING the salient features of the osteology of the cranial vault, one may note, on the **upper aspect** (norma verticalis) the *sagittal suture* in the mid-line, ending in front at the *bregma* where it intersects the *coronal suture* and behind at the *lambda* where it touches the *lambdoid*

suture; the *parietal foramina*, one on each side of the suture and the *obelion* between them. The **anterior aspect** (norma frontalis) (Fig. 160) presents the *frontal eminences* and between them the more or less distinct indications of the *metopic* or *interfrontal suture;* the *superciliary ridges*, the *supraorbital arches* with their *internal* and *external angular processes* and the smooth elevation, the *glabella*, between the inner extremities of the arches. The **posterior aspect** (norma occipitalis)

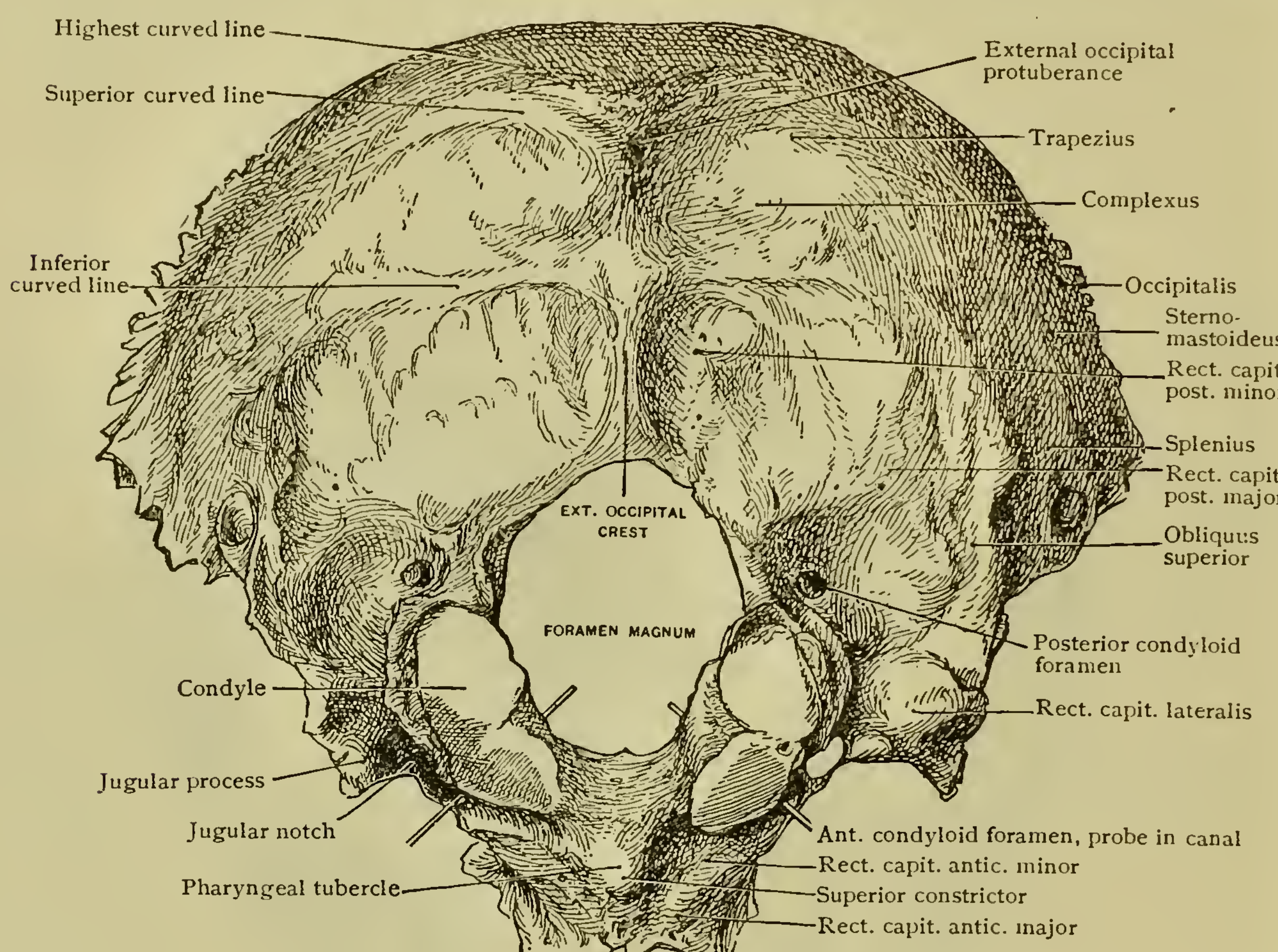

Fig. 161.—Outer surface occipital bone.

(Fig. 161) shows the *inion* or *external occipital protuberance*, the *three nuchal lines*, and the spaces between them; and the *external occipital crest.* Inspecting the **lateral aspect** (norma lateralis) (Fig. 162) one notes the *parietal eminences*, the *superior* and *inferior temporal ridges* —the *superior* and *inferior stephania* being the points where the latter respectively intersect the coronal suture—the *zygomatic arch* and its *three roots*, the *temporal* and *zygomatic fossæ* delimited from each other by the *infratemporal crest*, the *external auditory meatus*, the *mastoid process*, and the *ramus of the mandible* and its relation to the zygomatic arch.

THE SURFACE ANATOMY.

For the study of the surface anatomy of the scalp, it is necessary that the hair be removed by shaving or close clipping. An effort should be made to recognize by touch the various bony prominences enumerated above, most of which are easily palpable and constitute important landmarks.

DISSECTION.

With the cadaver lying upon its back, the head supported by a block (Fig. 19), a median incision should be made from the root of the nose to the external occipital protuberance; a second from the root of the nose along the upper limit of the eyebrow to the top of the ear and thence to the external occipital protuberance, and a third extending vertically upward from in front of the external auditory meatus to the

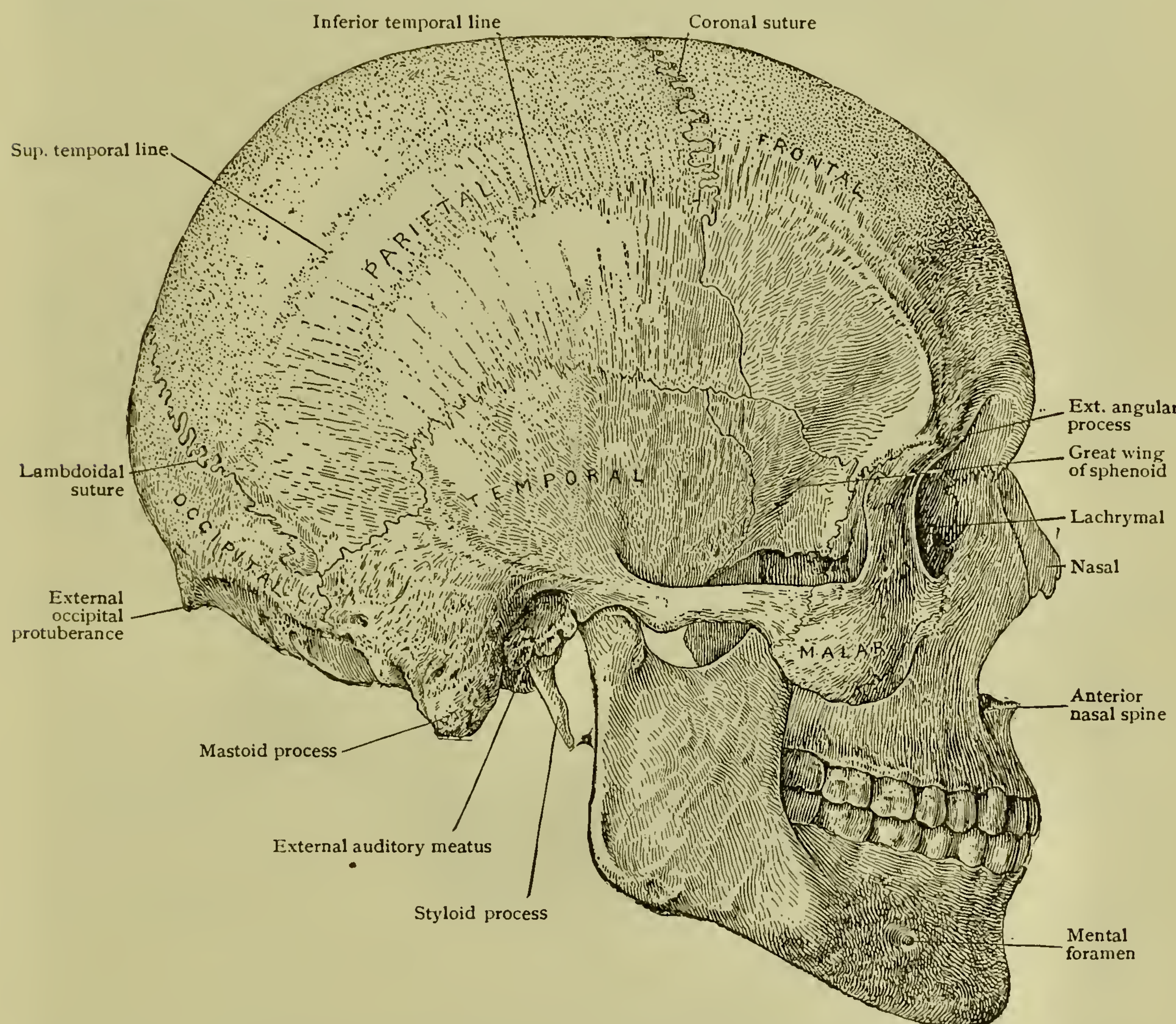

FIG. 162.—Lateral aspect of the skull.

median line. The removal of the posterior flap may be effected first by beginning at the upper corner and carrying the dissection downward and backward. Since the skin is very thick and is intimately adherent to the underlying superficial fascia, its dissection is difficult. The many hair-bulbs and sebaceous glands of the skin contribute to its denseness. The dissector must exercise care to avoid removing the superficial fascia with the skin; with this end in view the edge of the scalpel should be kept superficial to the fat, which, being a part of the superficial fascia, is a guide in

the recognition of the latter. The posterior flap having been removed, the anterior one may be reflected in like manner.

The thickness of the skin, the first layer of the scalp, prevents the occurrence of marked swelling and redness in inflammatory conditions such as erysipelas. The abundance of **sebaceous glands** in the skin accounts for the fact that *cystic tumors* of these glands (retention cysts) and the *wens* and *cutaneous horns* derived from them occur more frequently here than elsewhere.

The Superficial Fascia.—The superficial fascia, the second layer of the scalp, is not only closely adherent to the skin, but is also intimately

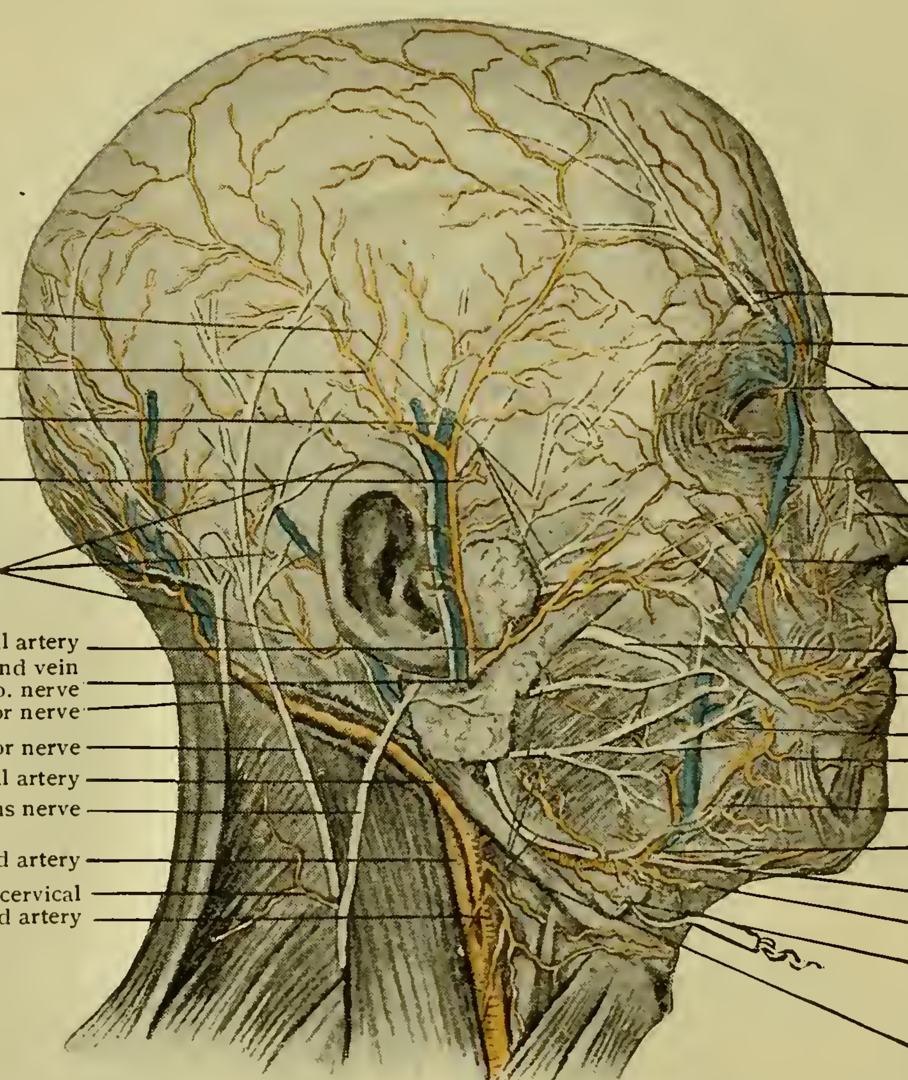

Fig. 163.—Dissection of vessels and nerves of face and scalp.

connected with the underlying aponeurosis of the occipito-frontalis so that these three layers move as one; a careless dissector may remove all three in attempting to remove the skin. The superficial fascia of the scalp is peculiar in that it contains the ramifications of the larger blood-vessels as well as of the larger nerves.

The **blood-vessels** of the scalp are the occipital, the posterior auricular, the superficial temporal, the supraorbital and the frontal arteries and their corresponding veins (Fig. 163).

The **nerves,** corresponding rather closely in position and in name, are the great occipital, the small occipital, the posterior auricular, the

auriculo-temporal, the temporal branch of the temporo-malar, the supra-orbital and the supratrochlear (Fig. 163).

The **great occipital nerve** (n. occipitalis major) (p. 344), accompanied by the occipital artery, emerges upon the superficial fascia just below the superior nuchal line of the occipital bone, having pierced the aponeurosis of the trapezius (Fig. 163), the artery when injected serving as a guide to the nerve. This nerve is the internal cutaneous branch of the posterior division of the second cervical nerve (Fig. 173). Passing upward it distributes branches in a radiating manner as far as the vertex of the skull.

The **third occipital nerve** (Fig. 173), supplying a small part of the scalp near the mid-line and the superior nuchal ridge, is the internal cutaneous branch of the third cervical nerve. If not easily found now it may be sought after the body has been turned over. The **posterior auricular branch of the facial nerve,** passing up behind the ear, supplies the posterior auricular muscle and the posterior belly of the occipito-frontalis and should be isolated if possible.

The **small occipital nerve** (n. occipitalis minor) (p. 350 and Fig. 163) will be found near the posterior border of the tendon of insertion of the sterno-mastoid muscle; its *auricular branch* may be followed to the posterior surface of the auricle; its other *branches* go to the skin of the scalp back of the ear.

The **occipital artery** (p. 371), a branch of the external carotid (Fig. 163) follows in the main the course of the great occipital nerve, anastomosing with the occipital artery of the opposite side and with the superficial temporal.

The **auricularis posterior muscle** (retrahens aurem) will be recognized as a patch of red discoloration behind the ear. It lies in and upon the superficial fascia, its **origin** being the mastoid process of the temporal bone and the outer part of the nuchal line; its **insertion,** the posterior surface of the concha (Fig. 164). Its dissection requires care.

The **posterior auricular artery,** a branch of the external carotid (p. 372), after leaving the neck reaches the groove between the cartilage of the ear and the mastoid process and divides into the *auricular* and *mastoid terminal branches*. Its **stylo-mastoid branch** will be encountered in the dissection of the neck (p. 378). The **mastoid branch** will be found passing backward over the upper part of the sterno-mastoid muscle to supply the scalp; the **auricular branch** will be exposed by removing the posterior auricular muscle; it sends *branches* to both surfaces of the auricle.

The **auricularis superior muscle** (attollens aurem), lying upon or within the superficial fascia above the ear, is even more delicate than the preceding and presents as a fan-shaped discoloration, the muscular fibres being exposed by careful removal of the small amount of overlying connective tissue. The **origin** is the temporal fascia or the galea aponeurotica; the **insertion,** the cartilage of the auricle.

The **auricularis anterior muscle** (attrahens aurem), a somewhat similar fan-shaped expansion in front of the ear, is similarly situated and must be similarly treated. Its **origin** and **insertion** are the same as the preceding. These muscles are rudimentary in man and are all supplied by the facial nerve, the posterior one by its posterior auricular branch.

The **superficial temporal artery** (Fig. 163), one of the terminal branches of the external carotid, passes upward in front of the ear across the root of the zygoma accompanied by its vein and by the **auriculo-**

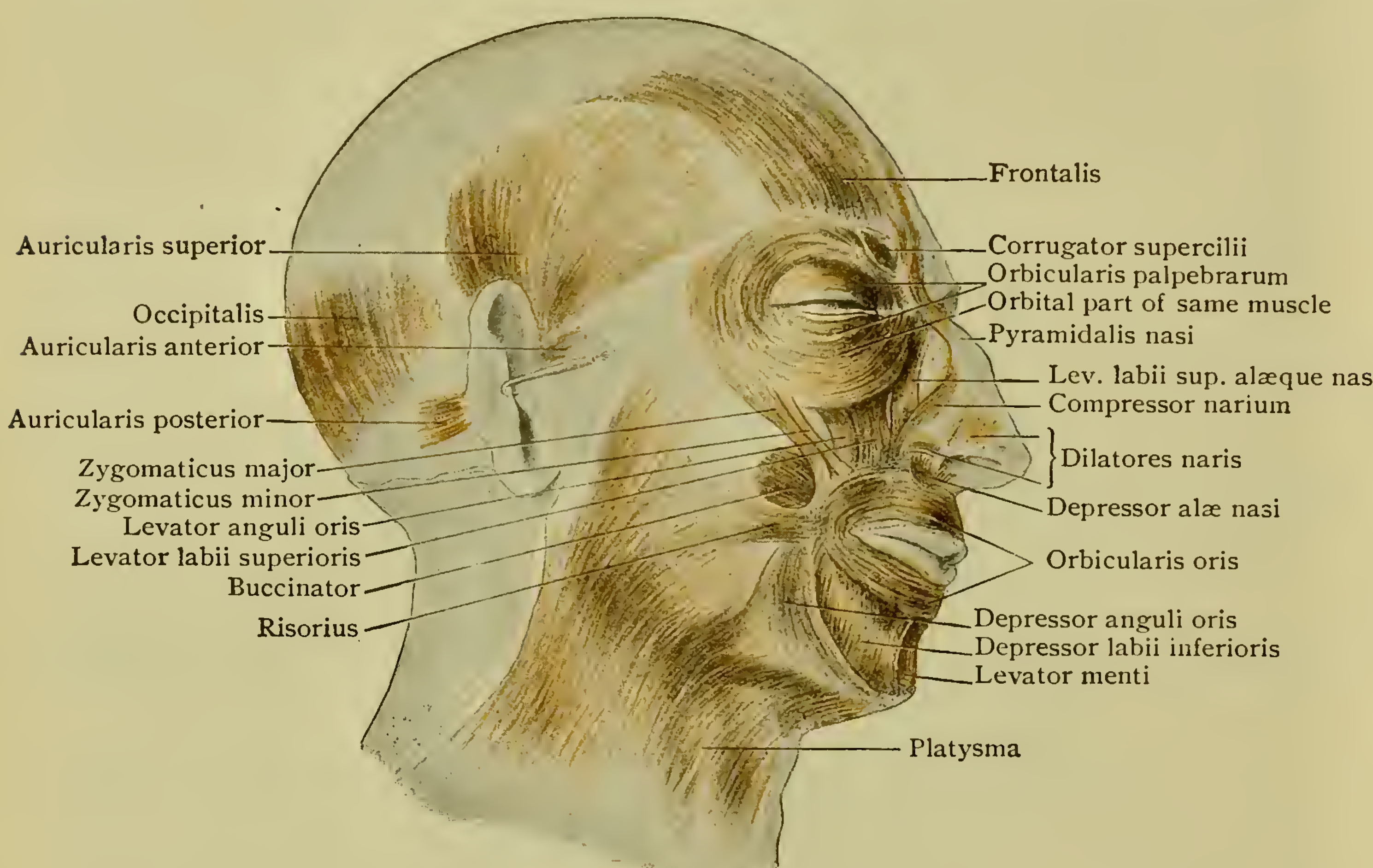

Fig. 164.—Platysma muscles (face muscles).

temporal nerve, which is behind it, a branch of the posterior trunk of the inframandibular division of the fifth nerve.

Beginning the dissection at the root of the zygoma, the vessels and nerve should be followed upward, the **artery** dividing into an *anterior* and a *posterior temporal branch*, the **nerve** also usually dividing into *anterior* and *posterior branches* which are distributed to the skin of the scalp.

The superficial position of the superficial temporal artery as it crosses the root of the zygoma in front of the ear makes it available for counting the heart-beats, as in anæsthesia, and caused it to be chosen frequently for the operation of **blood-letting** (in this case *arteriotomy*) in the days when such practice was more in vogue than it is at present.

The **supratrochlear nerve** (Fig. 163) will be found emerging from the upper inner extremity of the orbit to pass upward upon the fore-

head near the mid-line, distributing *branches* to the skin approximately as far as the hair-line. It is a terminal branch of the frontal nerve from the ophthalmic division of the trifacial.

The **frontal artery** (Fig. 163) emerges from the inner part of the orbit, being a terminal branch of the ophthalmic artery, and passes upward over the forehead to the vertex, distributing *branches* to the skin, the frontalis and the pericranium.

The **supraorbital artery** (p. 421), a branch of the ophthalmic, leaves the orbit through the supraorbital foramen in company with the supraorbital nerve and is distributed to the structures on the anterior part of the vault of the cranium (Fig. 163). It is accompanied by the supraorbital vein which receives the frontal diploic vein at the supraorbital foramen (Fig. 170).

The **supraorbital nerve,** a terminal branch of the frontal nerve from the ophthalmic division of the trifacial, emerges from the orbit through the supraorbital foramen with the supraorbital artery and lies at first under the frontalis muscle. Its *cutaneous branches* pierce the muscle or aponeurosis (Fig. 163) to be distributed to the skin as far as the vertex; the *pericranial branches* go to supply the pericranium.

The **temporal branch of the temporo-malar nerve** will be found in the upper anterior part of the temporal region which locality it reaches by piercing the temporal muscle and fascia (Fig. 163).

The nerves of the scalp are notably subject to neuralgia from irritation of other parts supplied by the same parent trunks or whose nerve-supply communicates with these trunks. The headaches of eye-strain, of irritation in the external auditory canal, of carious teeth, and of inflammation of the accessory nasal sinuses are familiar examples.

The arteries of the scalp, by reason of their situation in the superficial fascia and the intimate association of this with the skin, might be looked upon for all practical purposes as belonging to the skin. Hemorrhage from a scalp wound, if a vessel of any size is involved, is apt to be unusually free because of the close association and the denseness of the superficial fascia and skin, factors which prevent the retraction of the cut ends of the severed vessel as well as the lessening of the calibre of the vessel, two of the essential factors in the checking of hemorrhage being thus eliminated. The arteries of the scalp are subject to dilation and elongation, constituting **arterial varix** or **cirsoid aneurism;** if the capillaries participate, the disease is known as **racemose aneurism** or **aneurism by anastomosis.**

THE OCCIPITO-FRONTALIS (m. epicranius). This structure consists of two muscular portions or "bellies" connected by a broad aponeurosis which covers the top of the skull. It constitutes the third layer of the scalp. The **origin** of the posterior portion, or *occipitalis*, is the outer two thirds of the superior nuchal line and the mastoid process by tendinous fibres; its **insertion** is the aponeurosis. The **origin** of the *frontalis* is the anterior border of the aponeurosis, and its **insertion,** the skin of the forehead and the orbicularis palpebrarum, the median fibres being prolonged upon the nose as a muscular band which has been described as a

distinct muscle, the **pyramidalis nasi** (m. procerus). Some anatomists claim for it an attachment to the nasal bones and the external angular processes of the frontal (Fig. 163).

The **epicranial aponeurosis** (galea aponeurotica) is a tough fibrous structure which not only unites the muscular bellies but is continued downward on each side over the temporal fascia to be attached to the zygomatic arch. The mobility of the occipito-frontalis is easily demonstrated and is possible because of the loose-meshed tissue which underlies it (Fig. 165).

Having completed the dissection of the vessels and nerves, the occipito-frontalis and its aponeurosis should be cleaned.

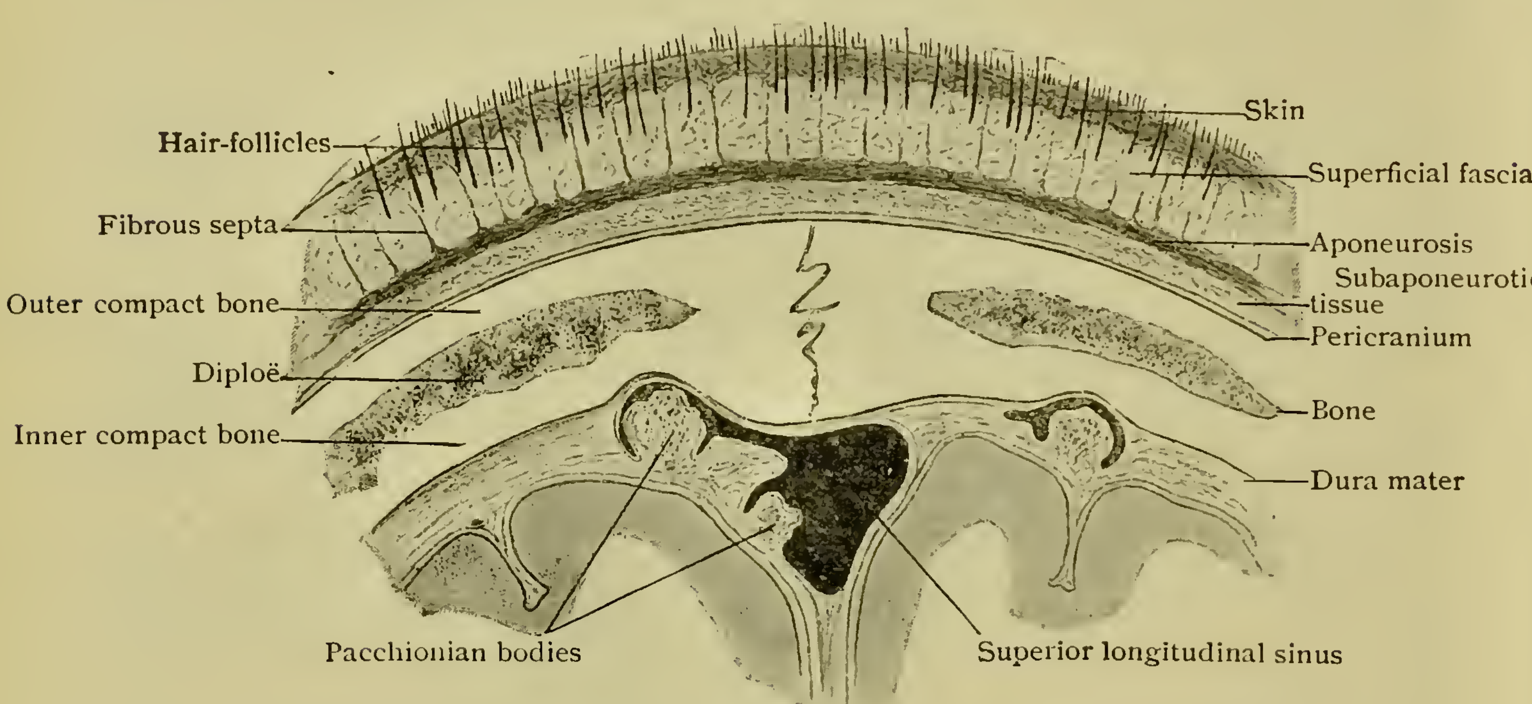

FIG. 165.—Portion of frontal section of head hardened in formalin, showing layers of scalp, skull, and meninges. × 2½.

The intimate relation between the skin, the superficial fascia and the occipito-frontalis enables these three layers to move as one upon the underlying loose, cellular, subaponeurotic tissue. In transverse wounds of the scalp involving the aponeurosis there will be much gaping of the wound.

THE TEMPORAL REGION.—The skin and superficial fascia having been removed from the region of the temporal fossa in common with its removal from the rest of the skull, the lateral prolongation of the epicranial aponeurosis mentioned above should also be removed, an incision for this purpose being made in a curved direction, convex upward, from the external angular process of the frontal bone to the base of the mastoid process. The flap thus outlined may be carried downward toward the zygoma, thus exposing the **temporal fascia** (Fig. 194). In dissecting this flap the nerve-trunks of the region already isolated should, of course, be preserved.

The **temporal fascia** now appears as a dense, glistening membrane attached below to the upper border of the zygomatic arch, and above, behind and in front to the superior temporal ridge. An incision along the upper border of the zygoma through the superficial layer of the fascia may now be made, when it will be found that at a short distance above the zygoma this flap joins a deeper layer of the same fascia which is attached to the inner edge of the upper border of the zygomatic arch, the fascia in its lower limits consisting of two distinct layers. A little fat and a small artery running forward, a branch of the superficial temporal, will be found between these two layers. The deeper layer may now also be incised and reflected upward so as to expose the temporal muscle.

THE TEMPORAL MUSCLE (Fig. 191).—**Origin,** the walls of the temporal fossa including the deep surface of the temporal fascia and the inferior temporal ridge; **insertion,** the coronoid process of the mandible; **nerve=supply,** two or three deep temporal branches of the anterior trunk of the inferior maxillary division of the fifth which enter the deep surface of the muscle; **action,** to elevate the mandible (one of the muscles of mastication).

The **fourth layer of the scalp,** the **subaponeurotic areolar tissue layer,** will be exposed upon removal of the aponeurosis of the occipito-frontalis. This may be removed by making an incision along the mid-line of the vault of the skull and another incision vertically upward from a point in front of the external ear to the mid-line, when the two flaps may be reflected forward and backward respectively.

The loose-meshed character of this subaponeurotic tissue has been referred to on page 320 as being the reason for the free mobility of the first, second and third layers. Because of its looseness, suppuration in this region is apt to spread so that a collection of pus may dissect up the entire "scalp" and may produce bagginess over the eyebrows or above the superior nuchal line or above the zygoma. The facility with which pus spreads in this region has won for it the name of the *dangerous area of the scalp*. It is because of the looseness of this layer that portions of the "scalp," *i.e.*, the first, second, and third layers, may be torn off, as in the case reported by Agnew, by violent traction upon the hair.

The **pericranium** or external periosteum of the cranial bones is the *fifth layer of the scalp* and presents as a special feature its continuity with the internal periosteum, which is the outer layer of the dura mater, through the various sutures, the tissue included between the sutures being known as the *intersutural membrane*. Although in the adult skull this intersutural membrane is reduced to the minimum, yet the pericranium is bound down over the sutures and therefore a collection of pus or blood between the pericranium and the bone would be limited by the outline of the particular bone over which it was situated.

The continuity of the pericranium with the internal periosteum is one explanation of the extension of inflammation upon the exterior of the bones to the membranes of the brain, the conveyance of septic material or of the inflammatory process along

the lines of emergence of the emissary veins (see page 337) being another. Although the pericranium has something to do with the nourishment of the bones, these derive their principal nourishment from the internal periosteum; consequently, destruction of the pericranium results in the production of only a superficial necrosis.

Defective union of the bones of the cranial vault with each other, or of different parts of the same bone, results in *congenital fissures* through which may protrude the membranes of the brain, forming a tumor beneath the scalp, **meningocele**; or of a part of the brain mass itself, **encephalocele**; or of a portion of a distended ventricle of the brain, **hydrencephalocele.** Such protrusions occur most commonly through a median cleft in the lower half of the tabular portion of the occipital bone (Treves, Sutton), but also at the fronto-nasal suture and in other localities.

THE REMOVAL OF THE BRAIN.

Assuming that the student has as yet no knowledge of the brain, a few important facts must be brought to his attention.

The brain is made up of four subdivisions, the **cerebrum,** the **cerebellum,** the **pons Varolii** and the **medulla oblongata** (Fig. 166). The **cerebrum** consists of two lateral hemispheres partially separated from each other by a space passing dorso-ventrally, the *great longitudinal fissure*, the hemispheres being partially connected with each other by a compact mass of fibres, the *corpus callosum* (Fig. 235), which constitutes the floor of the middle two thirds of the great longitudinal fissure; in front of and behind the corpus callosum the hemispheres are completely separated from each other by the fissure. The anterior extremity of the hemisphere is the *frontal pole;* the posterior extremity is the *occipital pole;* the forward-projecting prominence on its under surface is the *temporal pole* (Fig. 166). The surface of each hemisphere is marked off by depressions or grooves, the *fissures* or *sulci*, which lie between convex elevations of the surface which are known as the *convolutions* (Fig. 166).

The entire brain is enclosed by three **membranes** named from without inward the *dura mater*, the *arachnoid mater* and the *pia mater*. The **dura mater,** fibrous and tough, is prolonged into the great longitudinal fissure in the form of a sickle-shaped fold, the *falx cerebri* (Fig. 167), and into the space on the under surface of the cerebellum, between its two lateral hemispheres, as a much smaller fold, the *falx cerebelli;* while interposed between the under surface of the back parts of the cerebral hemispheres and the upper surface of the cerebellum is a dome-like extension of the dura mater, the *tentorium cerebelli* (Fig. 167).

With the cadaver lying upon its back, the calvaria or vault of the cranium should be removed by applying the saw in a line, marked by a cord tied around the skull, extending an inch and a quarter above the root of the nose in front, and one inch above the external occipital protuberance behind. In applying the saw, the dissector is made aware of having gotten through the outer table of the skull by the fact that the saw works more easily as it reaches the diploë. When the internal or vitreous table is reached the saw again works with a little more difficulty,

and when this is sawn through one is made aware of it by the greater ease of the work or the cessation of resistance. As this point is approached care should be exercised in order to avoid injuring the brain or its membranes. To more effectually safeguard these structures, the saw may be discarded when the diploë is reached, the vitreous lamina being broken through with chisel and hammer, aided by prying the

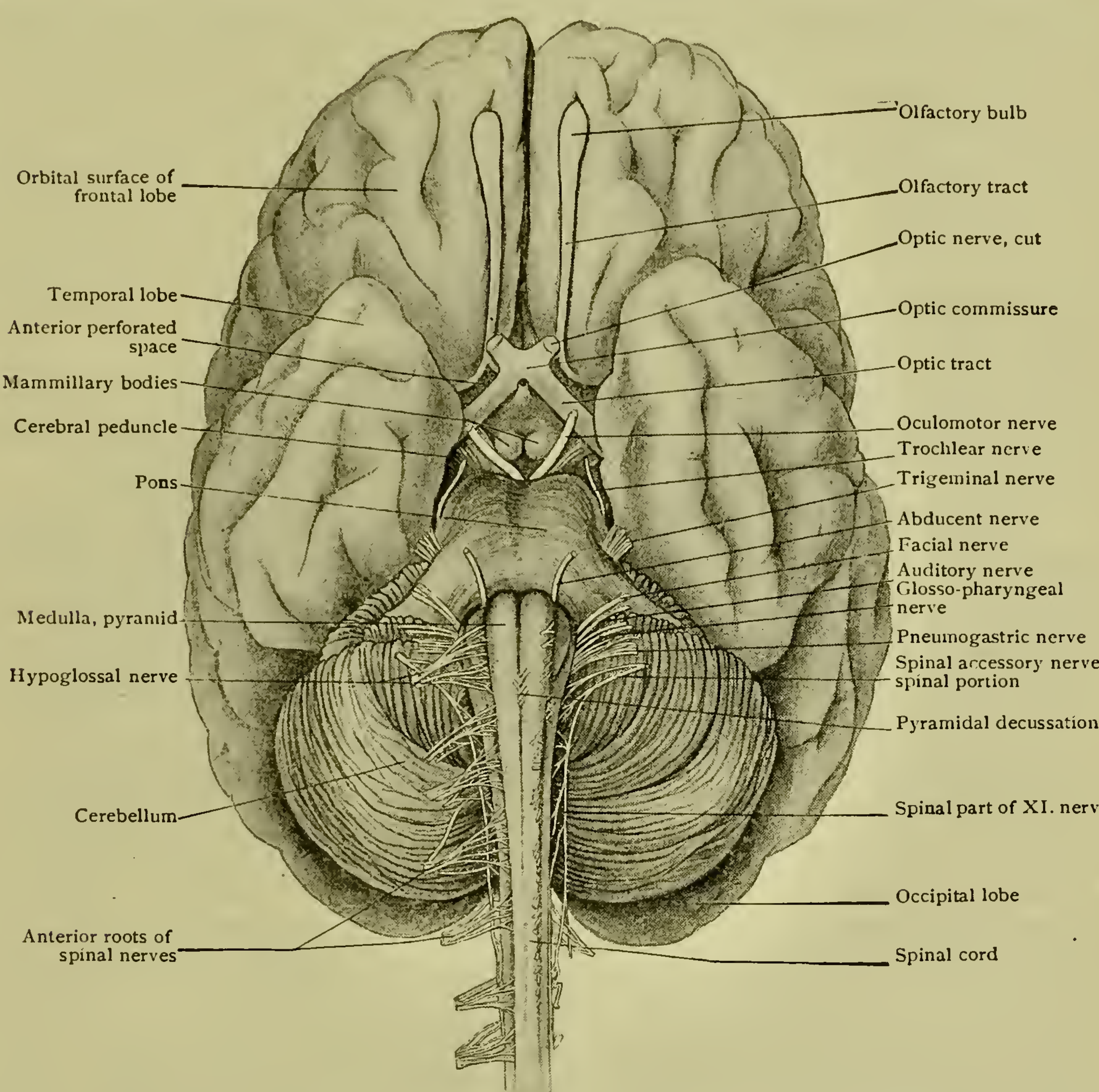

FIG. 166.—Inferior aspect of brain, denuded of its membranes, showing superficial origins of cranial nerves; origin of trochlear nerve is on dorsal surface and therefore not seen.

sawn edges of bone apart. The saw must be applied around the entire circumference of the cranium in order to make the section complete. When this has been effected the calvaria must be cautiously elevated with a blunt instrument and the adhering dura mater carefully peeled from the inner face of the bone. This may be done to best advantage with a blunt curved instrument, such as a urethral steel sound. The calvaria must not be discarded, as it finds important use at later stages of the work.

The Dura Mater.--The dura mater (Figs. 167 and 168), the outermost membrane of the brain, is a dense, fibrous structure, the outer layer of which constitutes the internal periosteum of the bones of the skull. The looseness of its association with the bones of the vault of the cranium has been demonstrated by the dissector in separating it from the calvaria, while the importance of this association is shown by the number of oozing points on the surface of the dura after its separation from the bones. As previously indicated (page 322) it is the chief source of nourishment for these bones. Being more intimately attached to the bones in childhood and in old age, it is adherent to the line of the sutures in any case, being continuous by means of the intersutural membrane with the pericranium. It is more closely associated with the bones at the base of the skull, the intimacy of this association being due in part to its sending sheaths or prolongations along the various nerves as they make their exit from the skull.

The looseness of the connection of the dura mater with the bones in the vault favors the extravasation of blood from a wounded meningeal vessel, constituting a collection of blood which is known as *extra-dural hemorrhage.*

The **meningeal arteries,** constituting the blood-supply of the dura mater, are derived from various sources, the *great* or *middle meningeal* and the *small meningeal*, branches of the internal maxillary artery, and the three *meningeal branches* of the ascending pharyngeal being the principal vessels, although the *lachrymal*, the *ethmoidal* and the *occipital* arteries also contribute meningeal branches.

The **middle** or **great meningeal** branch of the internal maxillary (Fig. 194) enters the skull through the foramen spinosum of the sphenoid bone and passing outward across the floor of the middle fossa of the skull divides into an *anterior* and a *posterior* branch. The dura mater may be gently separated from the lateral portion of the skull by the fingers in order to follow this artery toward the point of its entrance. The *anterior* branch grooves the great wing of the sphenoid, the squamous portion of the temporal bone and the inferior angle of the parietal bone, giving off branches as it goes. The *posterior* branch, smaller, passes backward and then upward.

The middle meningeal artery is the most frequent source of **extra-dural hemorrhage.** It may be reached in such case by trephining at a point one and one half inches behind the external angular process of the frontal bone and one and one half inches above the zygoma.

The **small meningeal artery,** a branch of the internal maxillary (Fig. 194), enters the skull through the foramen ovale. The *meningeal branches* of the **ascending pharyngeal** enter, one through the anterior condyloid foramen, one through the jugular foramen and one through the middle lacerated foramen.

The Dural Sinuses.—The sinuses of the dura mater are passageways formed by the separation of its two layers along certain lines to form channels which convey venous blood.

The **superior longitudinal sinus** in the convex border of the falx cerebri (Fig. 167), beginning at the crista galli, extends along the mid-line of the vertex to the internal occipital protuberance, where it becomes continuous usually with the right lateral sinus and also to a lesser extent with the left lateral sinus. This vessel receives **tributaries** from the

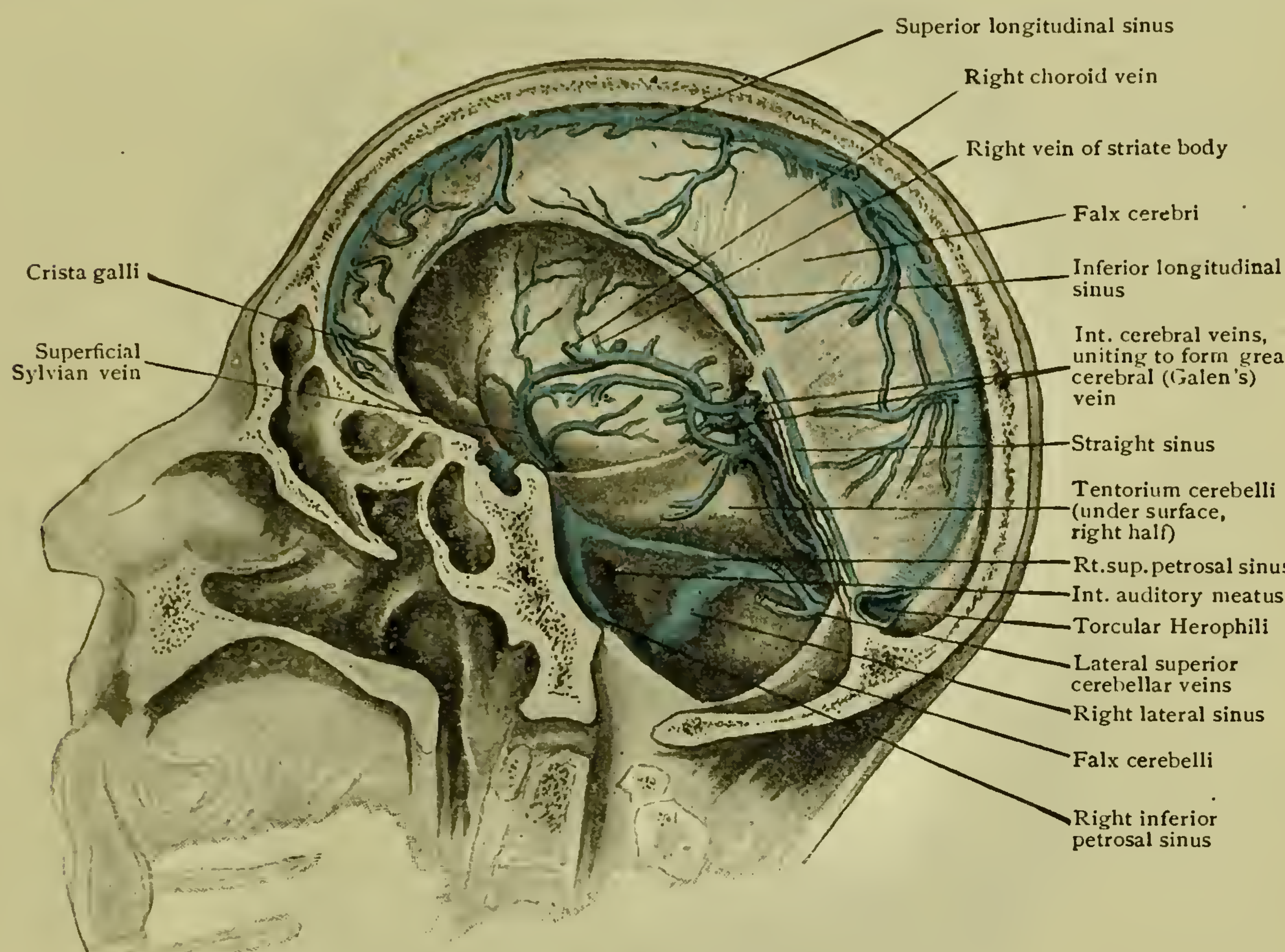

FIG. 167.— Head has been sectioned to left of mid-sagittal plane and brain removed, showing dural septa in position; terminal portions of some superior cerebral veins are seen upon the surface of falx cerebri.

mesial surfaces of the hemispheres as it passes backward (Fig. 167), these veins, however, passing from behind forward to open into the sinus. The superior longitudinal sinus may be punctured near its attachment to the crista galli and may be injected with a blue hardening mixture, such as the Pausch starch combination, unless it and the other sinuses and veins are already well injected. It will not be worth while to do this, however, unless twenty-four hours at least may be allowed for the hardening of the injecting material.

The **lateral sinuses** extend from the torcular Herophili at the internal occipital protuberance outward across the tabular part of the occipital bone, to lie successively upon the posterior inferior angle of the parietal

bone, the inner surface of the mastoid portion of the temporal, the petrous portion of the temporal, and again upon the occipital bone at the posterior margin of the jugular foramen. Through the posterior compartment of this foramen the sinus emerges from the skull to unite at once with the inferior petrosal sinus, thus forming the internal jugular vein (Fig. 168).

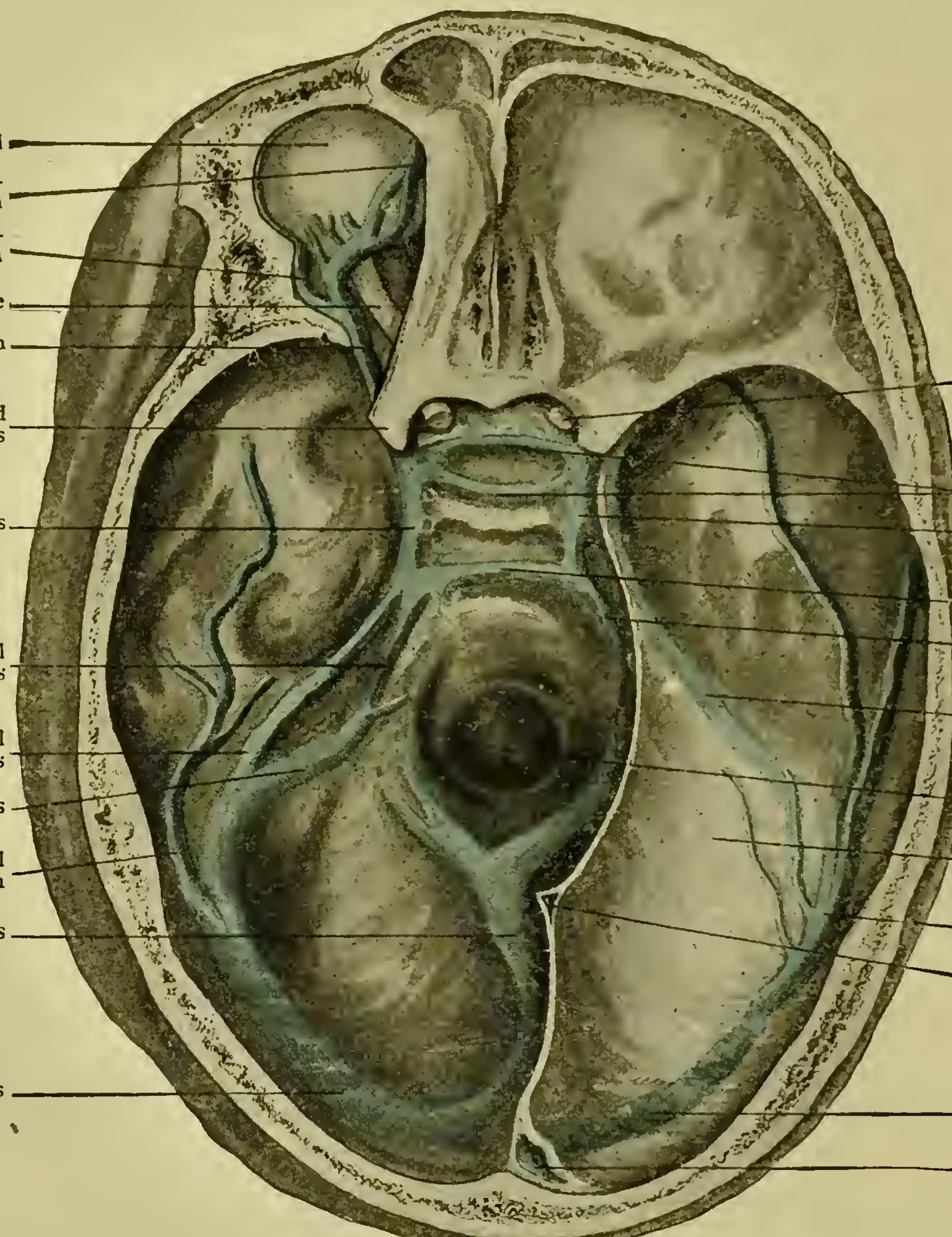

FIG. 168.—Dural sinuses at base of skull; falx cerebri and left half of tentorium have been removed.

The small masses seen apparently upon the surface of the dura mater in the vicinity of the anterior half of the superior longitudinal sinus are the Pacchionian bodies which are referred to on page 327.

The dura mater should now be cut upon the left side of the mid-line so as to avoid the superior longitudinal sinus, the incision beginning at the crista galli and extending to the internal occipital protuberance.

The **falx cerebri** (Fig. 167) is a sickle-shaped median process of dura mater projecting between the two hemispheres of the cerebrum and is

brought to view upon making the incision just directed. It is attached in front to the crista galli and behind to the upper surface of a dome-shaped portion of the dura mater, the tentorium cerebelli (Fig. 167), which separates the upper surface of the cerebellum from the back part of the cerebrum.

The **inferior longitudinal sinus** is in the concave border of the falx (Fig. 167), terminating by uniting with the two veins of Galen at the anterior limit of the tentorium, thus forming the **straight sinus,** which is situated at the line of attachment of the falx to the tentorium and which terminates behind in the torcular Herophili.

An incision should now be made through the dura mater on the right side of the superior longitudinal sinus, a transverse incision being made on each side extending from the middle of the sinus toward the root of the zygoma, the four flaps of membrane thus indicated being then reflected toward the sawn edge of bone. The **subdural space** is thus exposed. It is a narrow space containing a small amount of fluid and lies between the dura mater and the arachnoid.

The Arachnoid and the Subarachnoid Space.—The arachnoid is a rather loose-meshed membrane or, more properly, tissue between the dura mater and the pia mater, related by its superficial aspect, as stated above, to the subdural space and by its deeper aspect with the **subarachnoid space,** which contains the **cerebro=spinal fluid.** This space, or, more properly, series of spaces, is bridged across by slender bands of arachnoid tissue and is lined with endothelial cells. It presents several enlargements or dilatations, as the *cisterna magna*, the *cisterna pontis*, and the *cisterna basalis* (p. 331), and is continuous with the spinal subarachnoid space, and, through the foramen of Magendie and the foramina of Key and Retzius situated in the back part of the roof of the fourth ventricle, it communicates with the fourth ventricle and so with the general system of ventricular spaces of the brain. The transparency of the arachnoid membrane reveals the underlying pia mater with its system of blood-vessels, as well as the convolutions of the cerebrum. If one gently picks up the arachnoid with forceps, it is seen that this membrane does not dip into the fissures and sulci of the surface of the cerebrum but passes over them, the subarachnoid space being therefore augmented in this somewhat irregular manner by the surface inequalities of the cerebrum. These enlargements of the subarachnoid space, as also the larger spaces or cisterns at the base of the brain, may be partially demonstrated by inserting a canula into the space, having picked up a fold of the arachnoid with forceps, and injecting a colored hardening mixture.

The Pacchionian Bodies.—The Pacchionian bodies are projections from the arachnoid which are accommodated by the shallow depressions seen on the inner surfaces of the frontal and parietal bones, near

the superior longitudinal sinus, and sometimes in the neighborhood of other sinuses, composed of arachnoid tissue the meshes of which are occupied by the cerebro-spinal fluid. They project into the superior longitudinal sinus or into the **parasinoidal spaces,** the lateral diverticula of the sinus, and thus come into close relation with the venous blood of these channels. It is to be noted that they invaginate without actually penetrating the wall of the sinus (Fig. 165). This arrangement permits of the passage of the cerebro-spinal fluid into the venous blood, thus relieving intracranial pressure.

The Pia Mater.—This membrane appears now as a semi-transparent structure closely investing the surface of the brain and plentifully supplied with blood-vessels. It is called the vascular membrane of the brain, being the bearer of the vessels destined for the nourishment of that organ. So intimate is its relation to the brain that it dips into all the inequalities of its surface, the fissures and sulci, and, in certain regions, invades the brain ventricles in the form of richly vascular folds, the choroid plexuses. Its outer surface, bounding the subarachnoid space, is clothed with endothelial cells. It should not be disturbed at this time. The **cerebral veins** on the convex surface of the hemispheres should be noted, however, as passing upward toward the longitudinal fissure and turning forward upon reaching it to empty into the superior longitudinal sinus directly in opposition to the course of the blood stream of the sinus itself.

The Removal of the Brain.—This should now be effected, after having severed the attachments of the falx to the crista galli, by gently raising, with the fingers, the anterior poles of the cerebral hemispheres from the anterior fossa of the skull, a procedure which will be facilitated by allowing the head to drop well back. On either side of the mid-line of the anterior fossa, extending backward from the crista galli and lying upon the cribriform plate of the ethmoid, the cylindrical **olfactory bulbs** will be found. These should be raised with the frontal lobes of the cerebrum, and the numerous **olfactory nerve-fibres,** the **first pair of cranial nerves,** attached to the under surface of the bulbs, should be torn or cut. A little farther back, lying upon the optic groove of the presphenoid, is the **optic chiasm** or **commissure,** a rounded, cylindrical elongated structure placed transversely, from either end of which the **optic nerve,** the **second pair of cranial nerves,** passes forward and outward to enter the optic foramen. These nerves should be severed close to the foramen, and the **ophthalmic arteries** which pass through the same foramina with the nerves should also be divided. Elevating the cerebrum still more, the **pituitary body** will be encountered as a globular mass reposing in the sella Turcica and connected by a thin stalk, the infundibulum, with the under surface of the cerebrum. This should be removed with the brain and must be handled with extreme care

because of its delicacy. The horizontal perforated layer of dura mater, the **diaphragma sellæ,** which covers the sella and the pituitary body, should be incised to such extent as may be necessary to permit of the removal of the pituitary body. The **oculomotor nerve** or **third cranial,** the more slender **trochlear** or **fourth cranial nerve,** concealed from view by the border of the tentorium which should be displaced outwardly to expose the nerve, and the **abducens** or **sixth cranial nerve** will be found at the lateral margin of the dorsum sellæ—the sixth nerve traversing the notch below the posterior clinoid process—and should be divided at this place. The structures mentioned should be severed on both sides of the brain, but not too close to it so that sufficient may be left of each to identify both its attachment to the brain and its point of exit from the skull.

Turning the head of the subject now to the left, the right side of the back part of the cerebrum should be elevated, when the tentorium cerebelli will come into view lying beneath the posterior portions of the hemispheres.

The **tentorium cerebelli** (Fig. 167), a part of the dura mater between the back part of the cerebrum and the upper surface of the cerebellum, is attached to the periphery of the posterior fossa of the skull, including the posterior clinoid process of the sphenoid; this line of attachment is called its *attached margin.* The line of attachment, beginning at the internal occipital protuberance, extends along the margins of the groove reaching from this prominence horizontally outward to the lateral angle of the occipital bone and from here passes to the lower posterior angle of the parietal bone. The attached border to this point encloses the **lateral sinus** of the corresponding side (page 325). The attached margin includes the whole length of the upper border of the petrosa also, along which line it encloses between its separated layers the **superior petrosal sinus.** From the apex of the petrosa it extends forward and inward to the posterior clinoid process of the sphenoid.

The *anterior* or *free border* of the tentorium is deeply concave, forming the lateral and posterior margins of an oval aperture which is completed in front by the dorsum sellæ of the sphenoid bone. The aperture, the **incisura tentorii,** is for the transit of the mid-brain (cerebral crura). Each lateral portion of the free border is prolonged forward to acquire attachment to the anterior clinoid process of its own side. In passing forward it crosses that portion of the attached border which extends from the apex of the petrosa to the posterior clinoid process. The dissector should carefully verify these facts before proceeding further. Separating slightly the posterior poles of the cerebral hemispheres, the falx cerebri will be seen to be attached to the upper surface of the tentorium along its mid-line, this line of attachment corresponding with the straight sinus. The **straight sinus** (page 327), formed by the union

of the inferior longitudinal sinus with the veins of Galen, passes backward in the position indicated to terminate in the **torcular Herophili,** the latter being the confluence of the superior longitudinal, the straight and the occipital sinuses.

The tentorium may now be incised along its attached margins, making the cut not nearer to the bone than three quarters of an inch. To guard against injury to the cerebellum it is well to make the incision with scissors or by the cautious introduction of a scalpel blade beneath the membrane, entering the blade through the incisura, so as to cut it from below. This incision must include the posterior termination of the falx cerebri and the occipital end of the straight sinus so that the falx and the separated part of the tentorium may be removed with the brain. Now elevating the right side of the back part of the brain, including the cerebellum, the side of the pons and of the medulla will come into view and the dissector will note the presence of nerve-trunks emerging from the sides of these structures. The first of these, the **fifth** or **trifacial nerve,** consisting of a small motor and a larger sensory root, emerges from the side of the pons. At the upper part of the medulla in the groove between it and the pons, is the **seventh cranial nerve or facial,** in close proximity to which will be seen a smaller trunk, the **pars intermedia,** and close to this the **eighth cranial** or **auditory nerve,** these three structures passing to the internal auditory meatus, which they enter in company with a small vessel, the **auditory artery,** the eighth nerve being placed lowest and the seventh highest with the pars intermedia between. These three trunks should be cut a short distance from the internal auditory meatus. The **ninth, tenth** and **eleventh nerves** (respectively the glosso-pharyngeal, the pneumogastric and the spinal accessory) emerge by a series of strands from the dorso-lateral groove of the medulla (Fig. 169). The last named nerve is joined by a nerve that enters the skull through the foramen magnum, this being the spinal portion of the spinal accessory which, taking its origin from the spinal cord as far down as the sixth cervical nerve (Fig. 166), passes up to join the accessory or cerebral portion of the nerve as indicated above. The three nerve-trunks thus discovered pass together toward the middle compartment of the jugular foramen through which they make their exit from the skull. They may be severed near their point of exit. The **twelfth cranial nerve** or **hypoglossal** emerges from the ventro-lateral groove of the medulla between the olivary body and the restiform body and passes to the anterior condyloid foramen through which it escapes from the skull. This should also be cut near its point of exit. Turning the head of the cadaver to the right, the left side of the back part of the brain may be raised in the same way, and the corresponding nerve-trunks of the left side may be divided. The head should now be turned so that the face looks directly forward and, the

block having been removed from beneath the head, the latter must be allowed to drop back as far as possible, the brain, which now tends to roll backward out of the skull, being guarded and supported by the hand or the skull-cap. The spinal cord should be divided by a scalpel or scissors passed downward to a point below the lowest fibres of the nerves mentioned above. The **vertebral arteries,** which enter the skull through the foramen magnum and unite to form the single **basilar artery,** must also be divided, preferably at the level of the foramen magnum. When this has been accomplished the brain may be cautiously allowed to fall from its containing cavity into the operator's hands or the calvaria suitably held to receive it. It must then be placed in a preservative and hardening fluid, since it would not be possible to dissect it without preliminary hardening.

Before the brain is placed in the preservative fluid, however, the dilatations or *cisterns* of the subarachnoid space at the base of the brain should be examined, since the tearing or incising of the membranes which is necessary to permit the penetration of the fluid interferes with the satisfactory demonstration of the cisterns.

The Cisternæ Subarachnoidales.—The **cisterna pontis** is an upward continuation of the anterior part of the spinal subarachnoid space and is in relation with the ventral surface of the pons. The **cisterna basalis** is enclosed by the forward and lateral continuation of the arachnoid from the upper part of the ventral surface of the pons to the prominent temporal poles and thence to the orbital surfaces of the frontal lobes, bridging over the space between these and also the beginning of the fissure of Sylvius and of the great longitudinal fissure. The cisterna basalis, therefore, contains the circle of Willis and underlies the structures of the interpeduncular space and is prolonged into the Sylvian fissures and the great longitudinal fissure, continuing in the latter to the dorsal surface of the corpus callosum. If the attempt to inject the subarachnoid space proved successful, these cisterns will be sufficiently indicated by the presence of the injected material, and may be further demonstrated by removing the delicate arachnoid membrane and clearing away the injected material, thus exposing the circle of Willis. The **cisterna magna,** the largest of the subarachnoid cisterns, is situated between the dorsal surface of the medulla and the ventral surface of the cerebellum; it may be demonstrated by gently elevating the lower end of the medulla, the brain still being in the inverted position, and noting that the space between these two structures is bridged over on either lateral aspect by the delicate arachnoid membrane, the latter passing from the cerebellum to the medulla without dipping in between them as the pia does. Removing the arachnoid, the cavity of the cistern is exposed and, if sufficient care is exercised in its removal, the **foramen of Magendie**—the aperture by which the cisterna magna

communicates with the fourth ventricle—may be identified in the mid-line of the roof of this cavity.

Noting the relations of these enlargements of the subarachnoid space, it will be seen that the most vital portions of the brain are protected by an especially voluminous layer of fluid, the importance of this arrangement being emphasized by the fact that the cisterna pontis is continuous over the lateral surfaces of the medulla and pons with the cisterna magna.

The preferable preservative fluid consists of alcohol or wood alcohol plus four per cent. of formalin. The vessel in which the hardening is done should be a glass specimen jar of proper size and shape, in the bottom of which a quantity of cotton may be placed so as to form a nest for the brain, which should be placed upon the cotton in the inverted position with a sufficient quantity of the preserving fluid to completely cover it. To insure thorough penetration by the fluid the membranes at the base of the brain should be incised in several places. The dissection of the brain will necessarily be deferred until the completion of the hardening process and, therefore, until after other stages of the dissection have been done.

The Dura Mater and Other Structures at the Base of the Skull.—Reviewing briefly the osteology of the superior aspect of the base of the skull, the dissector will note the subdivision of the space into three **fossæ,** the *anterior*, *middle* and *posterior*, and that the petrous portions of the temporal and the dorsum sellæ of the sphenoid mark the distinction between the middle and posterior fossæ, while the posterior borders of the lesser wings of the sphenoid and the olivary eminence define the middle from the anterior fossa.

The **posterior fossa,** on a lower level than the other two, presents the foramen magnum, the anterior and posterior condyloid foramina, the basilar process of the occipital and the dorsum ephippii, the jugular foramen and the internal auditory meatus as well as the transverse and longitudinal grooves and ridges for the attachment of the tentorium and falx cerebelli and the lodgement of the dural sinuses.

The **middle fossa** should be noted as including the basi-sphenoid, the great wings of the sphenoid and the squamous portions of the temporal bone and as presenting the foramina spinosum, ovale, Vesalii, rotundum, lacerum medius and lacerum anterius.

The **anterior fossa,** overlying the orbital and nasal cavities, including the orbital plates of the frontal with the cribriform plate of the ethmoid between and the presphenoid with its lesser wings, presents the optic foramen, the anterior and posterior ethmoidal foramina, the nasal slit and the foramina in the cribriform plate of the ethmoid.

Mention has been made (p. 324) of the close adherence of the dura to the bones at the base of the skull as compared with its relation to the bones of the vertex. In the *posterior fossa* the **falx cerebelli** (Fig. 167) is seen as a small vertical mesial fold or process of dura mater attached by its convex border to the occipital bone from the foramen

magnum to the occipital protuberance. It encloses within its attached border the **occipital sinus** (Fig. 168); this divides into two venous trunks at the posterior margin of the foramen magnum, the *marginal sinuses*, which drain into the internal jugular veins; it originates in the torcular Herophili. The tentorium cerebelli has been considered (p. 329); the dissector should now examine its attachments as there indicated.

The **lateral sinuses** (sinus transversi) may now be followed throughout their entire course (p. 325) beginning at the torcular (confluens sinuum), the right one being in many cases the direct continuation of the superior longitudinal sinus, and terminating at the posterior compartment of the jugular foramen (p. 326).

The internal jugular vein is regarded by some anatomists as being the continuation of the lateral sinus, and the inferior petrosal sinus as terminating in the vein.

The **tributaries** of the lateral sinus are the *posterior inferior cerebral veins* from the tentorial surface of the cerebral hemisphere, some of the *inferior cerebellar veins*, and the *superior petrosal sinus*, and, for the *sigmoid portion* of the sinus or the part lodged in the sigmoid fossa of the mastoidea, the *internal auditory veins*, by way of the internal auditory meatus, and the *mastoid vein*.

The lateral sinus may be *ruptured* in fracture of the skull, giving rise to extradural hemorrhage, ranking second in importance only to rupture of the middle meningeal artery as a cause of this condition. The proximity of the sigmoid portion to the mastoid cells and tympanum and its communication with the circulation of the former through the mastoid vein render the lateral sinus peculiarly liable to infection and resulting *septic thrombosis* as a complication or sequel of otitis media and mastoiditis; its communication with the exterior circulation through certain emissary veins (p. 337) as well as its direct continuity with the internal jugular vein lay it open to infection in cases of septic wounds of the head and neck.

The **course** of the sinus is indicated by a line from the inion to the asterion (p. 314) and thence to a point a half inch behind the lower margin of the external auditory meatus. Since the sinus is of considerable width, a margin of a half inch on each side of this line is to be allowed if the sinus is to be avoided in trephining.

The **superior petrosal sinus,** running along the upper border of the petrous portion of the temporal bone, beginning at the apex of that structure, terminates in the sigmoid portion of the lateral sinus.

The **inferior petrosal sinus,** beginning near the apex of the petrosa as the continuation of the cavernous sinus, passes along the lower part of the petrosa to reach the anterior compartment of the jugular foramen, through which it makes its exit to unite immediately with the lateral sinus to form the internal jugular vein.

The **transverse sinus** (plexus basilaris), frequently a plexus of sinuses, passes transversely across the dorsum sellæ connecting the beginnings of the superior petrosal sinuses.

At the anterior condyloid foramen the **twelfth cranial nerve** leaves and a **meningeal branch of the ascending pharyngeal artery** enters the cranial cavity and a branch from the same vessel enters at the jugular foramen. The **ninth, tenth,** and **eleventh nerves** are seen to pass out of the cranial cavity through the middle portion of the jugular foramen.

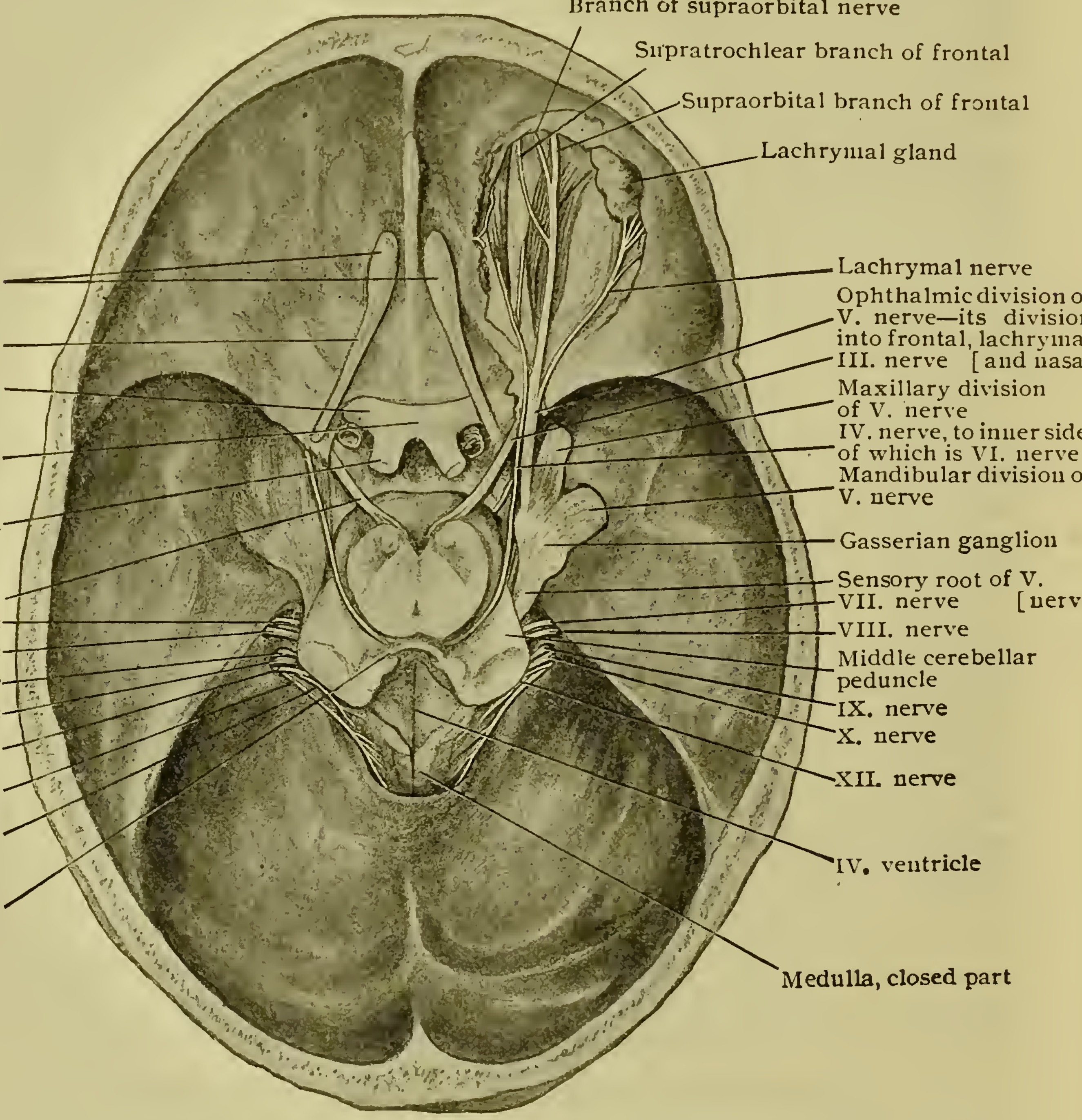

FIG. 169.—Base of skull, viewed from above, showing cranial nerves passing through dura; roof of right orbit has been removed to expose the ophthalmic nerve.

At the internal auditory meatus the **seventh** and **eighth nerves** and the **auditory artery** are to be noted as entering this aperture. At the posterior condyloid foramen, if present, **one of the emissary veins** may be found making its exit from the skull.

In the *middle fossa* the **cavernous sinus** occupies the cavernous groove on the side of the body of the sphenoid (Fig. 168). The **third,** the **fourth** and the **ophthalmic division of the fifth cranial nerves** should

be traced to the posterior end of this sinus which they enter to traverse its outer wall in the order indicated from above downward; the **sixth nerve** also enters the sinus but occupies a position more internal, close beside the internal carotid artery. The **internal carotid artery** should be found at its point of entrance into the skull through the carotid canal and traced to the back part of the cavernous sinus. These same structures should also be recognized as they issue from the anterior extremity of the sinus, the internal carotid artery giving off almost immediately its large **ophthalmic branch,**—which should be traced to the optic foramen through which it enters the orbit,—the other branches of the artery (p. 425) arising from that part of its trunk which was removed with the removal of the brain. The four nerve-trunks mentioned as traversing the cavernous sinus after leaving it, pass to the sphenoidal fissure, through which they leave the cranial cavity to enter the orbit. The **ophthalmic division of the fifth** divides, before entering the fissure, into its three terminal **branches,** the *frontal*, *nasal* and *lachrymal*. The **ophthalmic vein** coming from the orbit through the lower angle of the sphenoidal fissure enters the anterior extremity of the cavernous sinus. It will aid the dissector to identify these various structures if he recalls their relative position in the fissure, the fourth nerve being placed at the upper inner angle of the fissure, the lachrymal nerve at the upper outer angle and the frontal nerve between, while the upper division of the third nerve, the nasal nerve, the inferior division of the third nerve and the sixth nerve are arranged along the lower outer border of the fissure in the order here indicated. The outer wall of the cavernous sinus may now be removed so as to expose the structures mentioned as they lie within the sinus (Fig. 198). In removing the layer of dura mater constituting the outer wall of the sinus, it will be seen that this layer is connected by numerous bands and septa of connective tissue with the layer forming the inner wall so that the sinus is a mesh-work of spaces. The **circular sinus,** so-called, consists of two transverse channels which connect the cavernous sinuses of the two sides across the front and back parts respectively of the sella Turcica (Fig. 168).

The communications between the cavernous sinus and the pterygoid plexus by emissary veins, the connection of the ophthalmic vein with the cavernous sinus and the fact that this vein drains the orbit and communicates with the veins of the face explain the occurrence of infection of the intracranial venous channels and especially of *thrombosis of the cavernous sinus*, as a complication of infective diseases of the face, such as erysipelas and carbuncle.

The **Gasserian ganglion** (ganglion semilunare) lies upon the anterior aspect of the apex of the petrosa enclosed between two layers of the dura mater, the space it occupies being known as the **cave of Meckel** (cavum Meckelii). This ganglion belongs to the sensory root of the fifth nerve and is analogous to the spinal ganglia which are found on

the dorsal or sensory roots of the spinal nerves. The layer of dura mater which covers it may be cautiously removed. Unless the dissector works with great care he may find nothing after removing the dura, since the latter is closely adherent to the ganglion and the latter may be lacerated and taken up with the membrane. The ganglion contributes *meningeal branches* to the dura and communicates with the carotid plexus. The **sensory root of the fifth nerve** will be traced to the proximal side of the ganglion while the **motor root** will be seen to pass beneath the ganglion without any connection with it and to unite with a part of the sensory root on the distal side, the common trunk thus formed being the **third** or **inferior maxillary division of the fifth nerve,** which should be traced to the foramen ovale through which it makes its exit from the cranial cavity. The sensory root, emerging from the anterior aspect of the ganglion, divides into three parts, the **first** or **ophthalmic division,** the **second** or **superior maxillary division,** and the **third** or the **sensory portion of the inferior maxillary division.** The first and second divisions of the fifth are therefore purely sensory nerves, while the third division is both sensory and motor. Each division gives *branches* to the dura mater, the *recurrent branches of the ophthalmic* going to the tentorium, *those of the second and third divisions* to the dura of the middle fossa, the *recurrent of the third division* arising outside the skull and entering through the foramen spinosum with the middle meningeal artery.

The **Gasserian ganglion** may require *removal*, or the **sensory root of the fifth** *resection*, for intractable neuralgia of the trifacial nerve. The ganglion is reached through a trephine opening in the temporal region, the dura being stripped up from the floor of the middle fossa. The middle meningeal artery and the cavernous sinus are liable to injury in the operation.

The **great superficial petrosal nerve** from the geniculate ganglion of the facial (Fig. 204), emerging from the petrosa through the hiatus Fallopii, passes inward and forward in a groove on the petrosa beneath the dura to the middle lacerated foramen. It enters the cartilaginous substance which occupies this foramen and there unites with the great deep petrosal from the carotid plexus of the sympathetic to form the Vidian nerve (Fig. 219), which passes through the Vidian canal to reach Meckel's ganglion in the spheno-maxillary fossa. The **small superficial petrosal nerve** from the tympanic plexus of the glosso-pharyngeal and the geniculate ganglion of the facial emerges from the petrosa through a small aperture external to the hiatus Fallopii and passes through the foramen ovale, or sometimes a separate aperture, on its way to join the otic ganglion. The **small meningeal artery,** a branch of the internal maxillary, may be found entering through the foramen ovale (p. 324); the **middle meningeal artery** has been considered (p. 324).

In the *anterior fossa* the **cribriform plate of the ethmoid** should be noted with the related olfactory bulb and nerve-fibres already referred

to. Along the margin of the anterior third or half of the cribriform plate, the **nasal nerve** (Fig. 199), which enters the cranial cavity from the orbit through the anterior ethmoidal foramen, should be found. Passing directly forward the nasal nerve leaves the cranial cavity a second time to enter the nose through the slit at the side of the crista galli. The **anterior ethmoidal artery** may serve as a guide, if injected, to the nasal nerve, since it also enters the cranial cavity from the orbit through the anterior ethmoidal foramen, distributing *meningeal branches* to the dura mater of the anterior fossa; it is a branch of the ophthalmic artery. The **posterior ethmoidal artery,** likewise entering the cranial cavity from the orbit but through the posterior ethmoidal foramen, is situated about a half inch farther back.

The Emissary Veins.—The emissary veins are small vessels which connect the intracranial venous circulation with that exterior to the skull including the deep and superficial veins of the face. Some of these have been mentioned above and their clinical importance with reference to the extension of inflammation to the cranial contents, or conversely from the interior of the skull to the superficial structures, has been noted.

(1) The **parietal emissary vein** connects the superior longitudinal sinus with the scalp veins through the parietal foramen; (2) the **mastoid vein,** traversing the mastoid foramen, connects the lateral sinus with either the occipital or the posterior auricular vein; (3) the **occipital emissary** from the torcular or one of the lateral sinuses passes through the occipital protuberance to the occipital veins; (4) the inconstant **posterior condyloid emissary,** passing from the distal part of the lateral sinus through the posterior condyloid foramen, terminates in the vertebral veins; (5) the **anterior condyloid emissary** connects the inferior petrosal sinus with the vertebral veins through the anterior condyloid foramen, and (6) the **emissaries from the cavernous sinus** pass through the foramina ovale, Vesalii and lacerum medium to the pterygoid plexus and its tributaries.

The Diploic Veins.—The venous network of the diploë is connected on the one hand with the superficial venous circulation and on the other with the intracranial sinuses. The **anterior** or **frontal diploic vein** drains into the supraorbital vein at the supraorbital foramen (Fig. 170); the **anterior temporal diploic vein** terminates either in a deep temporal vein of the temporal fossa or the spheno-temporal sinus; the **posterior temporal diploic vein** opens into the mastoid emissary or sometimes into the posterior auricular vein; the **occipital diploic vein** drains either into the occipital vein or the occipital emissary.

The diploic veins are scarcely less important, as avenues of intracranial infection, than the emissary veins.

Noting the shape of the vault of the cranium, the manner in which the bones articulate with each other—the interlocking of the parietal bones at the sagittal suture

and the overlapping of the lower borders of the parietals by the bevelled borders of the squamosals and the great wings of the sphenoid being well calculated to resist force applied from above, while the overlapping of the anterior borders of the parietals by the frontal offers resistance to force applied from in front—and the construction of the bones of the vertex of two plates of compact bone with the intervening cancellous diploë, it will be seen that the form of the cranium is admirably adapted to the protection of the structures within.

Fractures of the vertex of the skull usually result from direct violence. It is noteworthy that when they spread to the base, as they often do, the suture-lines and the peculiarities of individual bones exert little or no influence upon the lines of fracture,

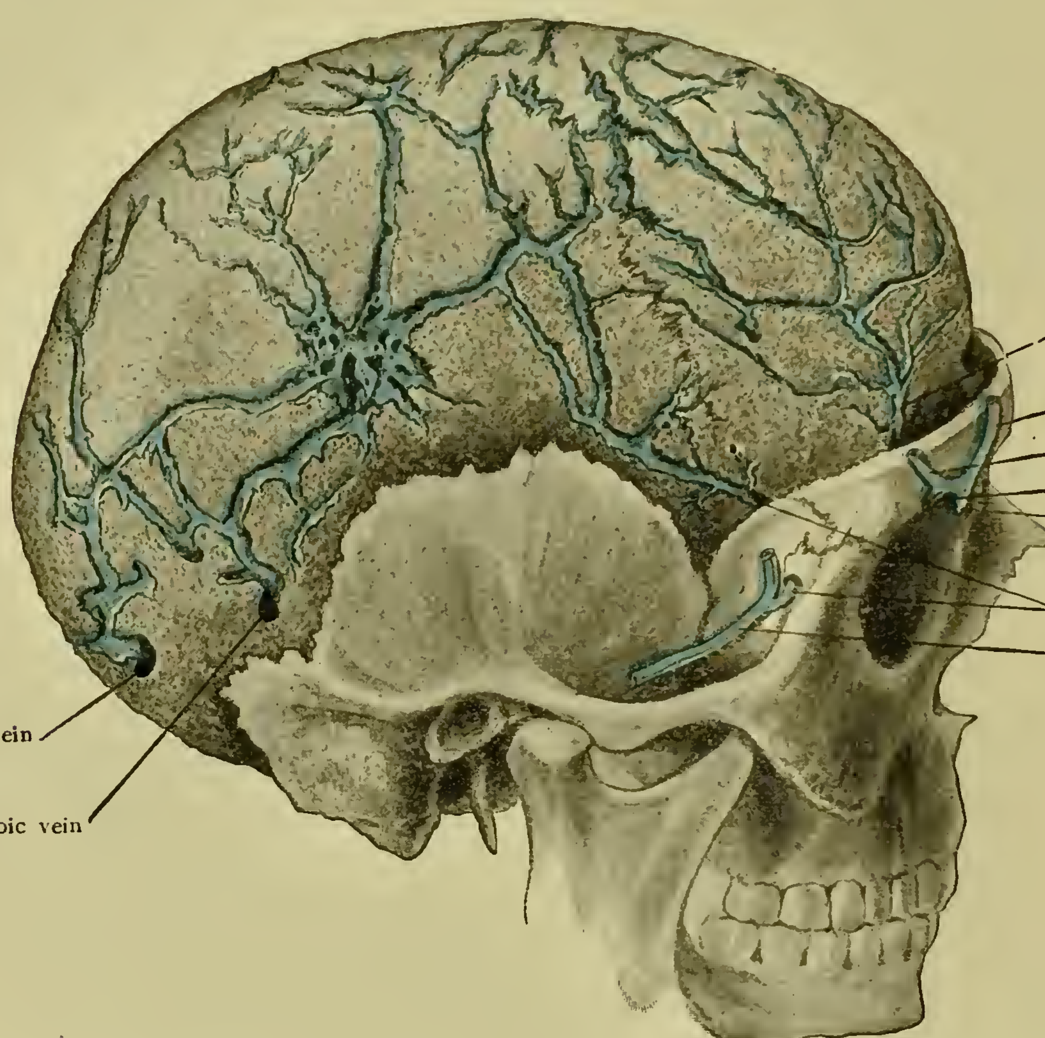

Fig. 170.—Outer table of skull has been removed to expose venous spaces of diploë.

the skull being affected as a whole. Fracture may occur *without displacement; with displacement* (depressed fracture); *with comminution;* or may be *compound.* The dura may be separated from the bone or may be torn, as may also the other membranes or the brain-substance.

Fractures of the base result from *direct* violence—foreign bodies thrust through the pharynx, orbit or nose, or a blow on the back of the neck—or from *indirect* violence, as falls or blows upon the chin, falls upon the buttocks, the flexed knees or the feet.

Let the student note the relation of the posterior fossa of the skull to the pharynx, of the middle fossa to the pharynx and nares and of the anterior fossa to the nares and orbital cavities, as well as that of the posterior and middle fossæ to the petrosa. Recalling the close attachment of the dura to the floor of the cranial cavity and the numerous important structures situated here, he will appreciate the gravity and be enabled to interpret the signs of such injuries.

Fractures of the posterior fossa are apt to be associated with the escape of cerebro-spinal fluid from the external auditory meatus, with ecchymosis at the nape of the neck and, if the basilar process or the basi-sphenoid be involved, with leakage of blood into the pharynx.

Fracture of the middle fossa may show escape of cerebro-spinal fluid from the external meatus, leakage of blood into the pharynx, and subconjunctival ecchymosis (discoloration of the palpebral conjunctiva from the presence of blood beneath it which has travelled forward through the sphenoidal fissure).

Fracture of the anterior fossa may be attended with effusion of blood into the pharynx, the nares or orbit and with escape of cerebro-spinal fluid through the nose if there be sufficient laceration of membranes.

The skull is now to be packed with damp gauze, the skull-cap placed in position and the scalp brought up over it and stitched in place that the parts may be preserved for later work upon the orbit and the organ of hearing. The body now being turned upon its face, the dissection of the back of the neck is to be done.

THE DISSECTION OF THE POSTERIOR REGION OF THE NECK.

The surface anatomy of this region is given at page 9. The superficial nerves, the trapezius and the levator anguli scapulæ are considered at pages 16 and 19. These structures may be worked out jointly by the dissectors of the head and of the upper limb. After the reflection of a part of the trapezius from its scapular and clavicular attachments—the caution is repeated not to disturb its outer portions, which would interfere with the study of the neck—the cervical portion of the splenius muscle is exposed and above and upon its inner side a small part of the semispinalis capitis or complexus (Fig. 171). In reflecting the trapezius, the cutaneous nerves already found superficial to it should be preserved, as they will serve as guides to their parent trunks; this may be done by disengaging them from the muscle at their points of perforation of the latter. The great occipital nerve pierces the complexus near its insertion into the occipital bone, the third occipital appears upon the surface of the splenius near the third spinous process, having perforated both it and the complexus, cutaneous branches from the third cervical nerve will be seen issuing from the muscle near the fifth dorsal spine and cutaneous branches of the fourth cervical near the seventh cervical spinous process. Having identified these nerves, the surface of the muscle should be cleaned, except its upper anterior part which enters into the floor of the occipital triangle of the neck.

THE SPLENIUS (Fig. 171).—**Origin,** the lower half of the ligamentum nuchæ and the spinous processes of the seventh cervical and the upper four, five or six thoracic vertebræ. **Insertion,** the *outer portion, splenius cervicis,* upon the posterior tubercles of the upper three cervical vertebræ; the *inner portion, splenius capitis,* the outer part of the superior nuchal line and the posterior border of the mastoid process. **Nerve-supply,** the posterior divisions of all the cervical nerves except the first.

Action, rotation of the cervical spine and of the head if one muscle acts alone; extension of the head and cervical spine if both muscles act.

The lower part of this muscle is covered by the serratus posticus superior (Fig. 171) and it cannot therefore be completely demonstrated

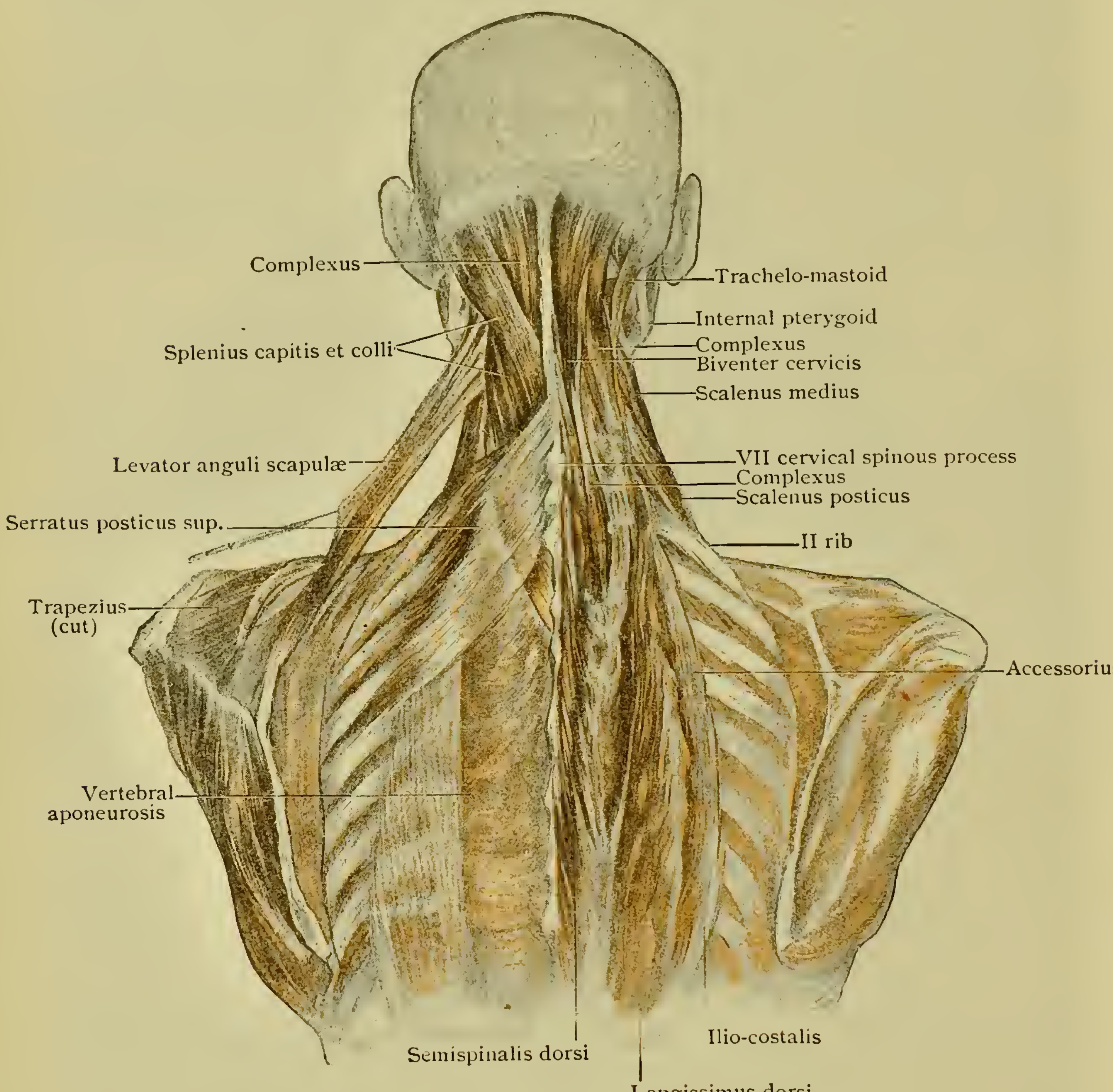

FIG. 171.—Dorsal, cervical, and thoracic muscles.

until the dissector of the trunk has taken up the latter muscle. When this has been done, the attachment of the splenius to the ligamentum nuchæ and the spinous processes may be severed and the muscle reflected outward. The upper part of the **vertebral aponeurosis,** which passes under the serratus posticus superior and covers the complexus (Fig. 171), is now exposed and, near the occipital bone, the **occipital**

artery, which may pass to the scalp externally to the outer border of the trapezius or may advance inward under that muscle and pierce it.

The **superficial branch of the arteria princeps cervicis** of the occipital passes downward under the splenius to form inosculations that will be seen later (p. 384). The **great occipital nerve** will be seen perforating the complexus near its upper extremity (Fig. 173) and the **third occipital nerve** near the mid-line and farther down, while other **cutaneous branches** of the posterior cervical divisions, previously encountered, are found emerging through the muscle still farther down. The fascia is to be removed from the complexus and the neighboring muscles, the **biventer** and the **trachelo-mastoid** (Fig. 171), with due regard to the safety of the nerves and the occipital artery.

The complexus and the slender two-bellied muscle internal to it, the **biventer cervicis,** really constitute one muscle, the **semispinalis capitis,** which is a part of the semispinalis (p. 585); it will be seen to pass from the transverse processes of the lower half of the cervical region and of the upper half of the thoracic region to the occipital bone between the nuchal or curved lines and adjacent to the external occipital crest. The trachelo-mastoid (p. 583), external to the complexus, passes from the lower cervical and upper thoracic region to the mastoid process. It cannot be fully dissected now without undue interference with the lateral neck region.

The complexus should be detached from its insertion upon the occipital bone and turned downward, with care for the preservation of the nerves and the arteria princeps cervicis branch of the occipital artery beneath it, the trachelo-mastoid being left in place. The nerves should be followed to their points of origin as well as this can be done without disturbing the occipital triangle of the neck.

The **arteria princeps cervicis,** a branch of the occipital, divides into the *superficial branch,* noted above, and the *deep branch.* The deep branch passes down the neck beneath the complexus and upon the semispinalis colli to anastomose with the arteria profunda cervicis of the superior intercostal (p. 385).

The Suboccipital Triangle (Fig. 172).—This small muscular triangle is exposed by the removal of the complexus. Its *boundaries* are the rectus capitis posticus major above and internally, the obliquus capitis inferior below and the obliquus capitis superior on the outer side. Each one of these muscles should be denuded as well as the limits of the dissection permit. Clearing away the fat and connective tissue which cover it, the vertebral artery and the posterior division of the suboccipital or first cervical nerve will be seen to traverse it. Cleaning up these structures will reveal the *floor* as the posterior occipito-atlantal ligament and the posterior arch of the atlas.

Rectus Capitis Posticus Major (Fig. 172).—**Origin,** the spinous process of the axis; **insertion,** the inferior nuchal line of the occipital bone and the surface of bone below it (Fig. 161); **action,** to draw the head backward and to rotate it.

Rectus Capitis Posticus Minor (Fig. 172).—**Origin,** the posterior tubercle of the atlas; **insertion,** the inner part of the inferior nuchal line (Fig. 161); **action,** to draw the head backward.

Obliquus Capitis Superior (Fig. 172). — **Origin,** the transverse process of the atlas; **insertion,** the occipital bone above the outer part of

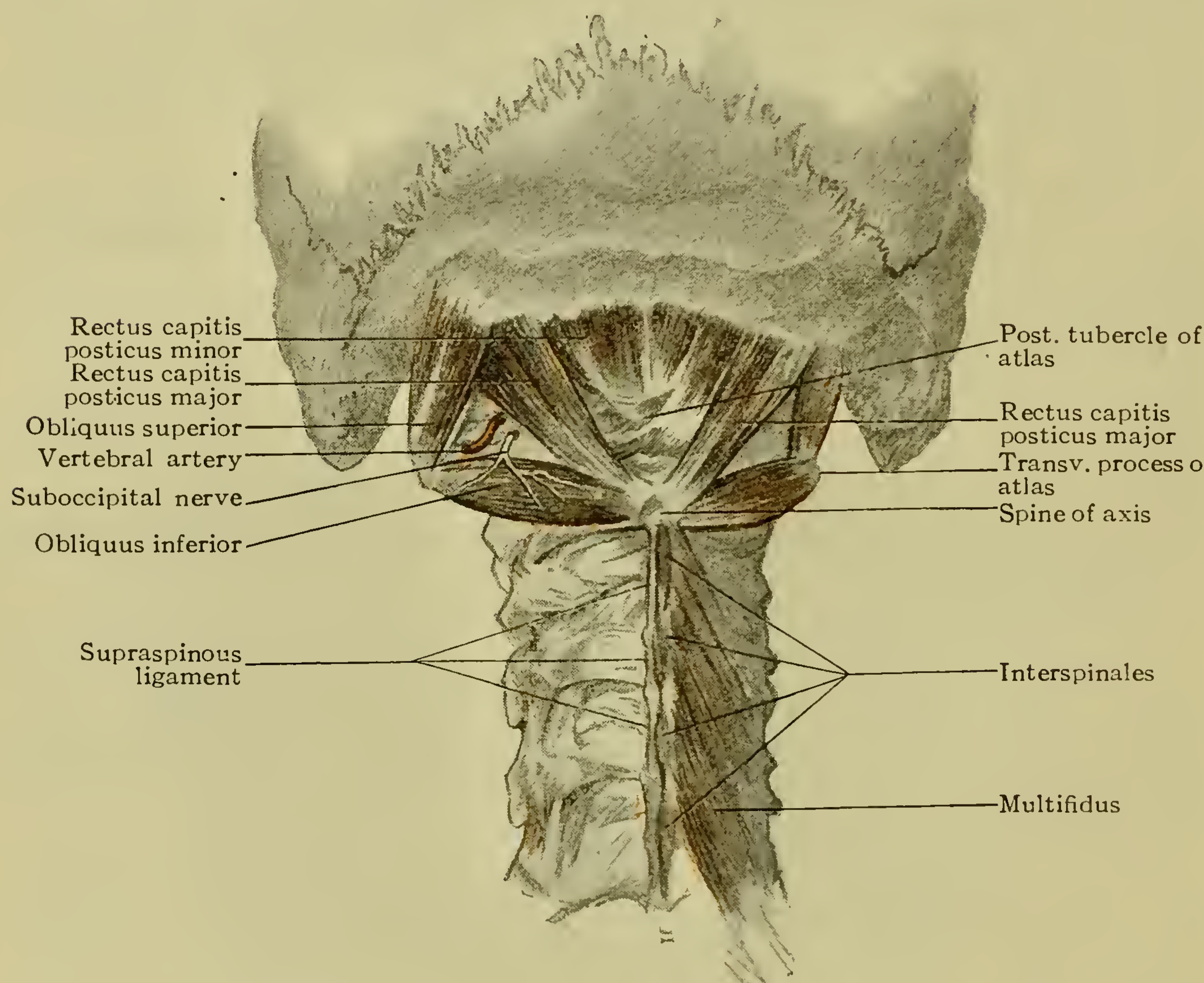

Fig. 172.—Deep dissection of neck, showing suboccipital group of muscles and suboccipital triangle containing vertebral artery and suboccipital nerve.

the inferior nuchal line; **action,** to draw the head backward and to aid the recti capitis laterales and the recti antici minores in steadying the occipital bone upon the atlas during rotation at the odonto-atlantal joint (p. 494).

Obliquus Capitis Inferior (Fig. 172).—**Origin,** the spinous process of the axis; **insertion,** the transverse process of the atlas; **action,** to rotate the axis toward the same side.

The **nerve=supply** of the four muscles noted above is from the posterior division of the suboccipital or first cervical nerve.

The Posterior or Dorsal Divisions of the Cervical Nerves.—Although these nerves cannot be completely worked out now, they may be mentioned here by way of summarizing the branches already encountered and noted above. The posterior or dorsal divisions of the cervical nerves except the first (p. 15) divide into an **internal cutaneous branch** (ramus medialis) and an **external muscular branch** (ramus lateralis) (Fig. 12). The communications between the dorsal division of the sub-

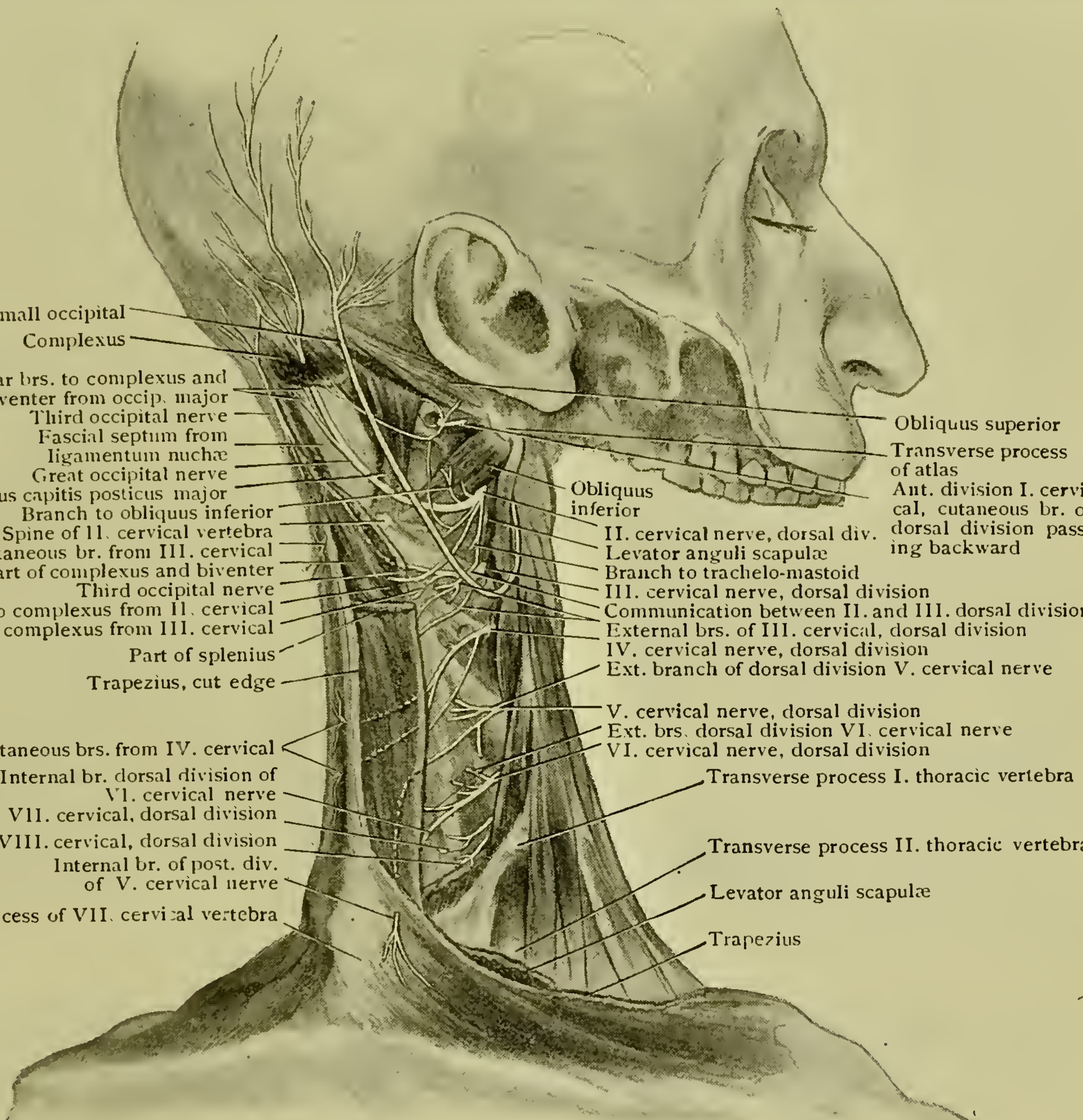

FIG. 173.—Dissection of right side of neck, showing deeper relations of cervical nerves.

occipital nerve and the cutaneous branches of the second and third dorsal divisions constitute what is sometimes called the **dorsal cervical plexus.**

The **dorsal division of the first cervical** or **suboccipital nerve** leaves the spinal canal between the occipital bone and the posterior arch of the atlas, traverses the suboccipital triangle below and behind the vertebral artery, distributes *muscular branches* to the complexus which covers it and to the two posterior straight and the two oblique muscles,

gives a *communicating branch* to the second cervical, usually to its great occipital branch, and pierces the complexus and trapezius as the *cutaneous branch* to accompany the occipital artery to the scalp. The cutaneous branch may be absent.

The notably large **dorsal division of the second cervical nerve,** emerging between the dorsal arch of the atlas and the lamina of the axis, passes below the inferior oblique muscle to the deep surface of the complexus where it divides into its *external muscular branch* (ramus lateralis) which supplies the inferior oblique, the complexus and the semispinalis cervicis and the *internal cutaneous branch* or *ramus medialis*, which is commonly known as the **great occipital nerve** (n. occipitalis major). Passing over the inferior oblique muscle, the latter nerve pierces the complexus (Fig. 173) and comes into relation with the occipital artery which it accompanies to the scalp, usually piercing the trapezius (Fig. 163).

The **dorsal division of the third cervical nerve** divides into the *lateral muscular branch* for the complexus, trachelo-mastoid and splenius (Fig. 173), and the *internal cutaneous branches*, some of which, after piercing the complexus, splenius and trapezius, are distributed to the skin of the neck (Fig. 11) while another, the *third occipital nerve*, piercing the same muscles supplies the skin of the back part of the scalp and the upper part of the neck (Fig. 11). Sometimes the third occipital nerve is as large as the great occipital; in other cases it is very small. The remaining posterior cervical divisions have been sufficiently considered.

The muscles still remaining on the dorsal aspect of the cervical spine may be disregarded by the dissector of the head. The dissection of the joints of the region may be deferred until after the separation of the head and neck from the trunk.

THE ANTERO-LATERAL REGION OF THE NECK.

THE SURFACE ANATOMY.

There is some advantage in dissecting the face before the neck, since the superficial structures of the face are more prone to deteriorate and since the dissectors of the upper limbs are at this time engaged upon the chest; but it seems more logical to dissect first the cervical vessels and nerves and trace them upward.

The **lower border of the lower jaw** is recognizable by sight as well as by touch; passing the finger downward from the symphysis of the jaw at the middle line, the body of the **hyoid bone** is encountered, the *great horns* of which may be felt by placing the finger and thumb one upon either side of the neck. Passing over a short interval below the hyoid

bone the palpating finger encounters the prominence of the **thyroid car=tilage of the larynx** (Fig. 174) (the "Adam's apple") and passing still farther downward one recognizes the **cricoid cartilage of the larynx.** By deep pressure to one side of the cricoid cartilage, a bony prominence may be felt, the **carotid tubercle** or **Chassaignac's tubercle,** the anterior tubercle of the transverse process of the sixth cervical vertebra. Returning to the middle line one may feel the soft prominence of the **thy=roid gland** and immediately below this the **trachea;** the latter sinks more deeply as the root of the neck is reached and here one encounters the **upper border of the sternum** with the **sternal extremity of the clavicle** on each side, these three bony surfaces marking the **suprasternal** or

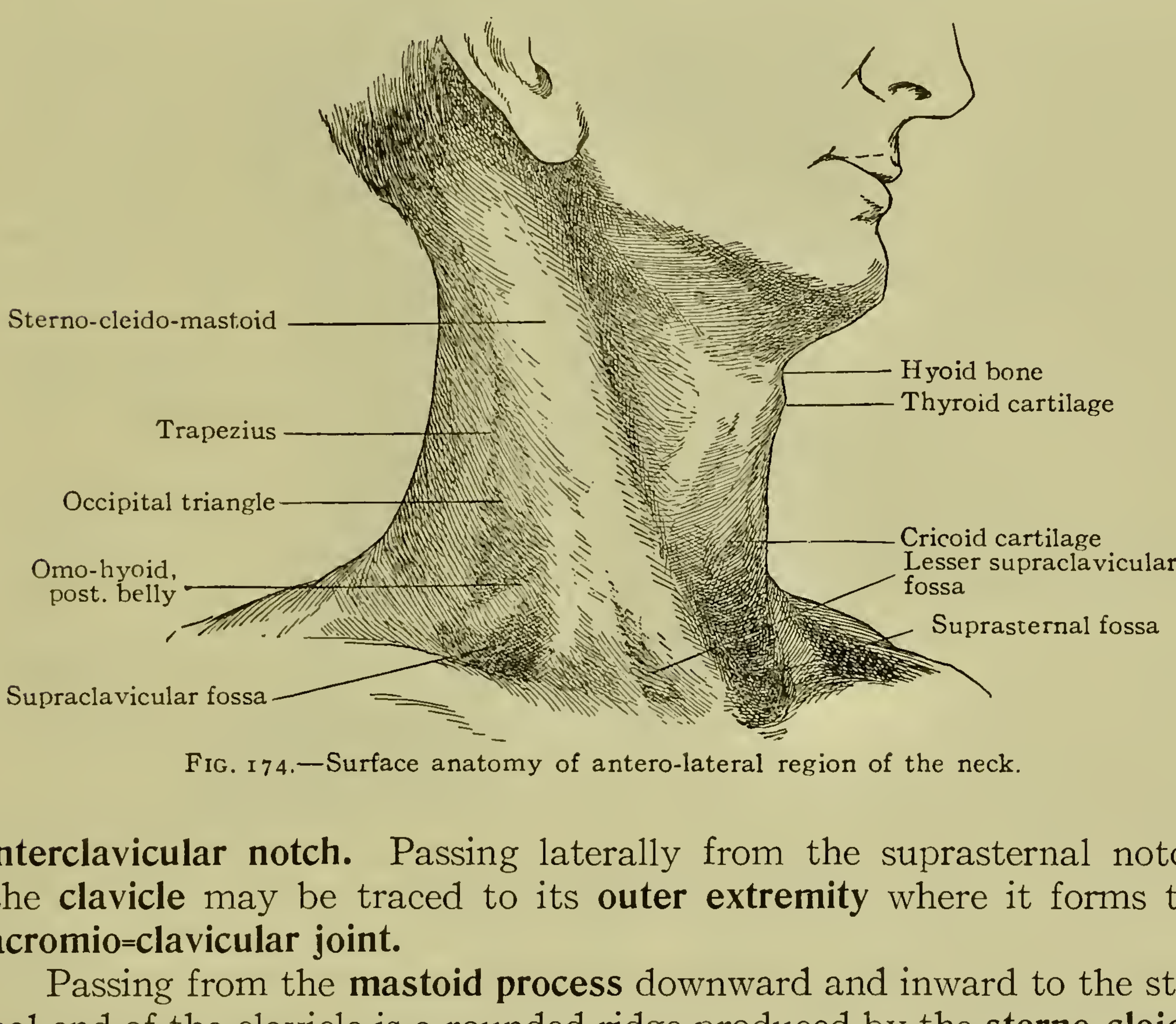

FIG. 174.—Surface anatomy of antero-lateral region of the neck.

interclavicular notch. Passing laterally from the suprasternal notch, the **clavicle** may be traced to its **outer extremity** where it forms the **acromio=clavicular joint.**

Passing from the **mastoid process** downward and inward to the sternal end of the clavicle is a rounded ridge produced by the **sterno=cleido=mastoid muscle,** which divides the lateral surface of the neck into an anterior and a posterior triangular space. In the living subject the **pul=sation of the common carotid artery** may be felt just beneath the inner border of the muscle below the level of the upper border of the thyroid cartilage. At the lower part of the posterior triangle, just above the clavicle, is a conspicuous depression, the **supraclavicular fossa,** by deep pressure upon which in the living subject the **pulsation of the subclavian artery** may be detected. This fossa is made deeper by drawing the

shoulders forward; under favorable conditions, the **posterior belly** of the **omo-hyoid muscle** may be seen as a prominent ridge extending upward and inward from a point external to the middle of the clavicle. In certain individuals with unusual muscular control, the **platysma myoides** may be made apparent as a superficial plane of muscular tissue beneath the skin (Fig. 175).

DISSECTION.

With the body lying upon its back, the upper part of the neck supported by a block so that the chin is elevated, a median vertical incision should be carried from the chin to the sternum; a second incision, along the lower border of the lower jaw and extended to the mastoid process, and a third, carried from the top of the sternum along the clavicle to the acromion process, should be added. The dissection should be begun at the upper median corner of the flap thus outlined, the head being turned to the side opposite that on which the dissection is to be made. The corner of the flap being grasped with the forceps, the skin should be removed without trespassing upon the underlying structures. With this end in view the knife-cuts should be made close to the under surface of the skin, the position of the head being altered from time to time as may be necessary to render the parts more tense, and the tissues being moistened occasionally if difficulty is experienced in separating the skin. The removal of this flap exposes the superficial fascia.

The Superficial Fascia.—The superficial fascia presents as a feature of special interest the extensive plane of muscular tissue, the **platysma myoides,** which may be seen shimmering through the fascia (Fig. 175). A dark streak extending from the angle of the jaw to the middle of the clavicle indicates the position of the **external jugular vein.** The presence of some filaments from the **superficial branches** of the cervical plexus is to be noted, and near the middle line of the neck will be seen the **anterior jugular vein.** In exposing these structures, begin along the line of the jaw a few inches from its symphysis to denude the surface of the platysma, carrying the dissection downward in the direction of the muscular fibres. This work is one of some delicacy as the fascia adheres rather closely to the muscle and the muscle itself is of somewhat delicate texture. As the region of the clavicle is approached, the dissector should look for the descending superficial branches of the cervical plexus; these are, near the acromial region, the **supra-acromial branches,** in the vicinity of the middle of the clavicle, the **supraclavicular branches,** and near the sternal end of the clavicle, the **suprasternal branches** (Fig. 176). These nerves usually perforate the platysma in the regions indicated and pursue their further course superficially to the muscle (Fig. 176); as recognized, they and their branches should be picked up and followed to their terminations. Near the inner border of

the sterno-mastoid muscle and about mid-way between the jaw and the sternum may be found another superficial nerve, the **superficial cervical,** perforating the platysma to gain a more superficial position on its way toward the upper and median portion of the neck. These nerves are frequently very difficult to detect but may usually be recognized as narrow, pearly bands embedded in the cellulo-fatty tissue.

The **platysma myoides,** having been denuded, its **origin** should be noted as being from the deep fascia of the chest, an inch or more below

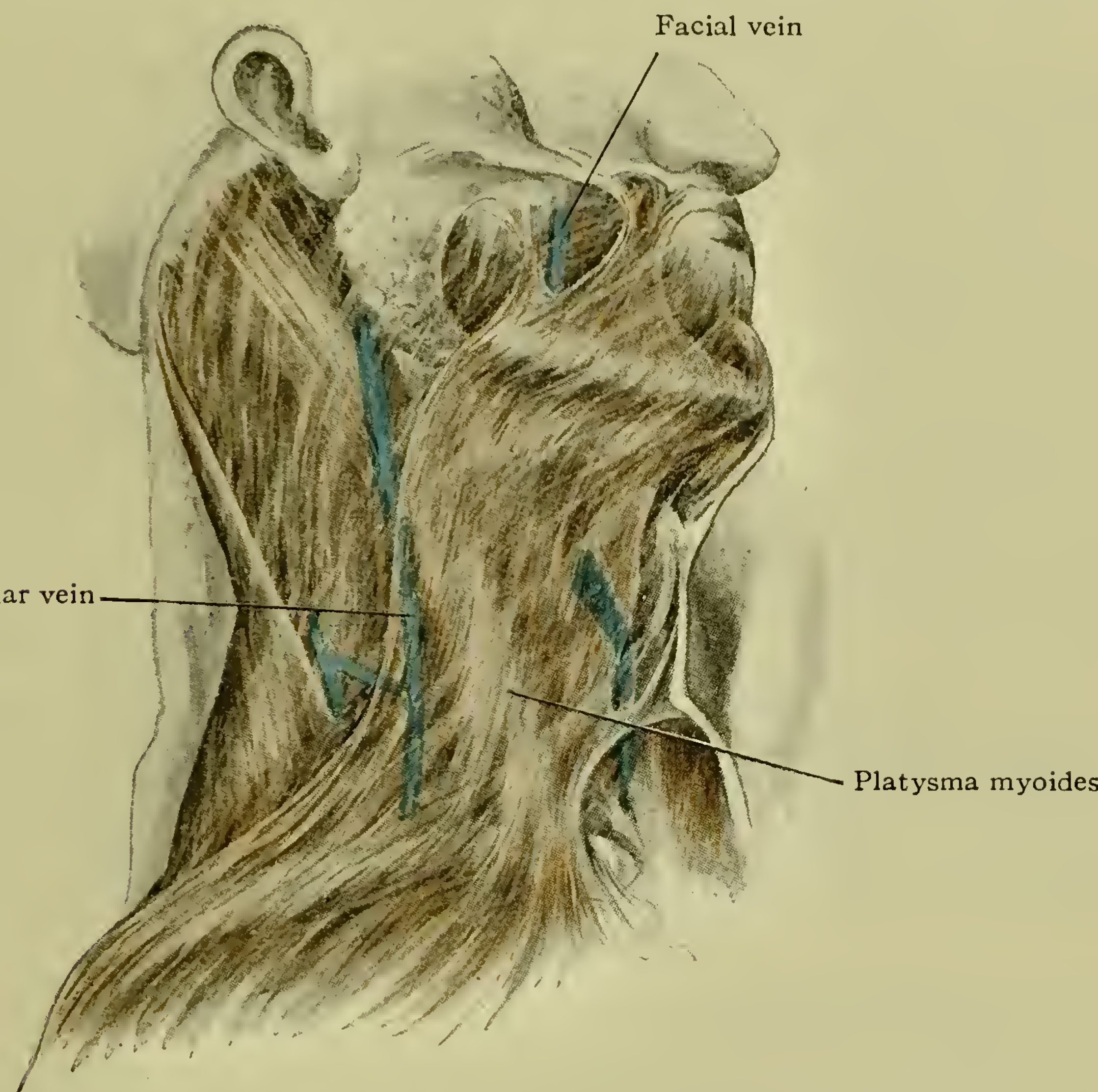

FIG. 175.—Superficial dissection of antero-lateral region of neck.

the clavicle, and from that of the acromial region (Fig. 175). The muscle, narrowing as it ascends, passes over the lower border of the mandible to be **attached** for the most part to that bone below the oblique line, some of its anterior fibres interlacing with those of the opposite muscle below the chin, while the more posterior fibres pass upward and forward to blend with other muscles at the angle of the mouth, the most posterior portion terminating in the deep fascia covering the masseter muscle.

An incision should now be made through the platysma along the line of the jaw and its reflection should be begun. This exposes the deep fascia

and should be effected with caution to avoid injuring underlying nerves. Near the upper part of the muscle will be found the **auricularis magnus** nerve (Fig. 178) which passes almost vertically upward, crossing the sterno-mastoid muscle from about the middle of its posterior border to a point just below the lobe of the ear; only in the upper part of this line, however, will the nerve be found upon the surface of the deep fascia, the point at which it pierces the fascia varying; about an inch below the lobe of the ear its first branch or branches may be given off. Along the

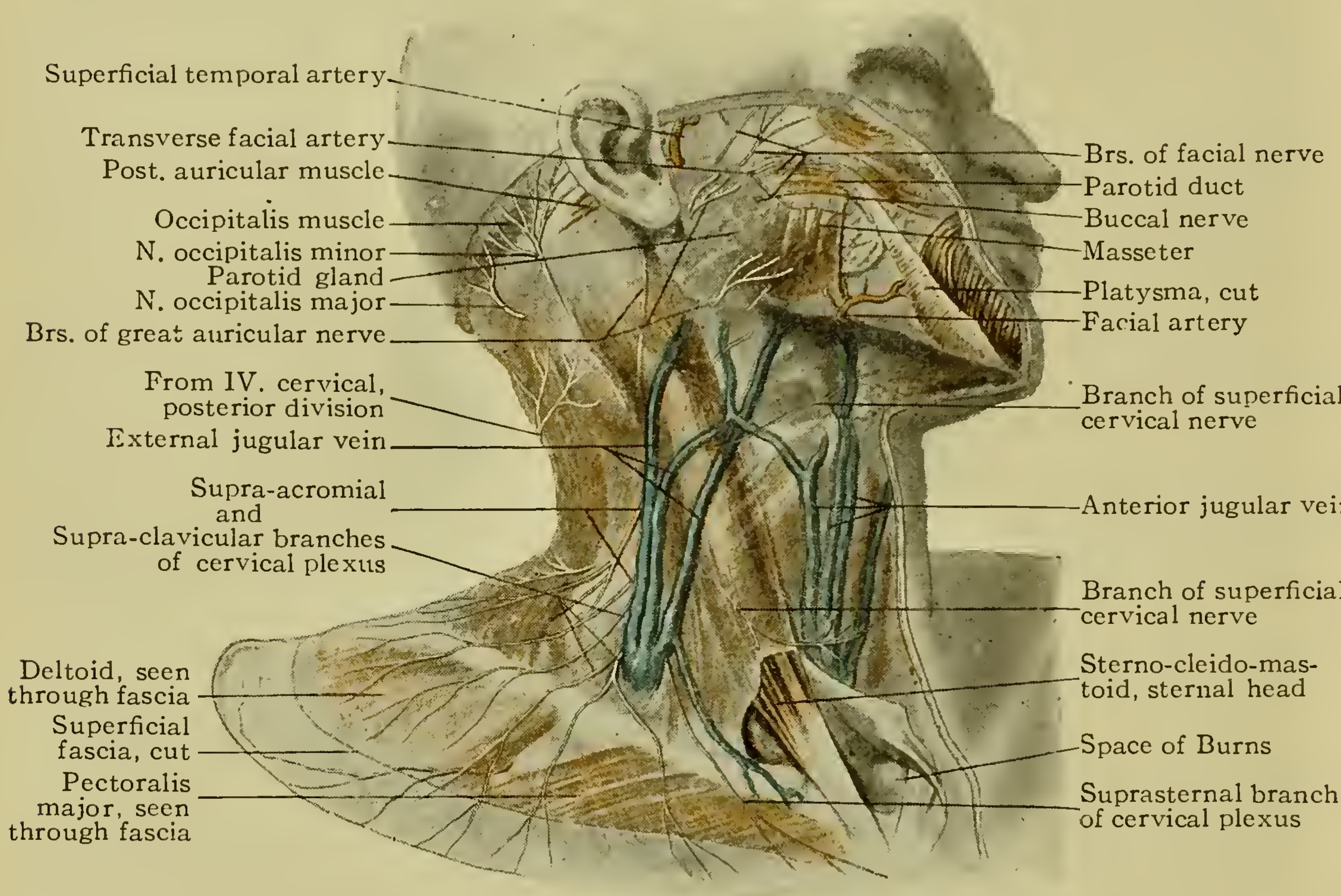

FIG. 176.—Superficial layer of deep cervical fascia, showing superficial nerves and vessels.

posterior border of the upper half of the sterno-mastoid will be found a smaller nerve, the **occipitalis minor,** which also will be found superficial to the deep fascia only in the upper part of its course. Crossing the sterno-mastoid about its middle from its posterior border should be found the **superficial cervical nerve** mentioned above. As the platysma is reflected farther, a superficial nerve may be found obliquely crossing the sterno-mastoid toward the sternal end of the clavicle; this is the **supraclavicular branch of the cervical plexus.** The suprasternal and supra-acromial nerves mentioned above come through the deep fascia not far from the clavicle.

The **anterior jugular vein,** beginning below the chin by the convergence of the inferior coronary, the mental and the submental veins, and pursuing its course downward close to the middle line of the neck to

terminate in the external jugular or the subclavian vein, should now be dissected down to the point where it disappears by piercing the deep fascia (Fig. 176). The anterior jugular veins of the two sides may be represented by one unpaired trunk, or by one on one side and two on the other, or by two veins on each side. The part of the superficial fascia between the anterior border of the platysma and the middle line of the neck should be removed from the deep fascia, care being exercised to detect a branch from the superficial cervical nerve which ascends toward the lower border of the mandible and which usually communicates in this situation with a branch of the facial (Fig. 178).

The **external jugular vein,** sometimes double (Fig. 176), the course of which has been indicated above, should now be divested of connective tissue.

It **originates** within the parotid gland by the confluence of the posterior auricular vein and the posterior trunk of the temporo-maxillary vein. Half an inch or more above the middle of the clavicle it perforates the deep fascia to terminate in the subclavian vein (Fig. 183). The enlarged part of this vein, the *sinus*, is that portion of it between the two sets of valves with which the vein is provided, which are located respectively at its termination and at a point about an inch and a half above the clavicle. Its chief **tributaries** are the *posterior external jugular* received near the middle of the neck and the *suprascapular* and *transverse cervical veins* near the clavicle and usually the *anterior jugular* at its termination.

The removal of the superficial fascia should be continued laterally to a point half an inch or more beyond the anterior border of the trapezius muscle. The superficial layer of the deep fascia is now exposed and the depressions marking respectively the upper and lower triangles situated posterior to the sterno-mastoid are more apparent.

The Deep Fascia.—The deep fascia of the neck consists of the **superficial layer** now exposed and of several **deeper layers** or **processes** (Fig. 176). This superficial layer (Fig. 177), beginning posteriorly at the nuchal ligament and the spines of the cervical vertebræ, passes around toward the anterior neck region, splitting on its way to enclose the trapezius muscle, again splitting farther on to enclose the sterno-mastoid muscle and then, after the union of its two layers, blending to a single sheet to be continuous across the mid-line anteriorly with the fascia of the opposite side. Above, it is attached posteriorly to the external occipital protuberance and the superior nuchal line, more laterally to the base of the mastoid process, the zygomatic arch and the lower border of the mandible, while below it is attached along the upper borders of the clavicle and sternum. The fascia, before reaching the sternum, again splits into two sheets which are attached respectively to the anterior and posterior borders of the upper piece of the sternum,

the space enclosed between these two sheets being known as **Burns' space.** This space contains the sternal head of the sterno-cleido-mastoid muscle and the anterior jugular vein passes through it.

Burns' space should now be exposed by making an incision about two inches in length along the upper border of the sternum and the inner extremity of the clavicle, a second incision being carried about two inches upward from the mid-line of the top of the sternum. This triangular flap may now be reflected, exposing the space of Burns and its contents (Fig. 176).

The **auricularis magnus nerve** may now be followed downward to its origin in the superficial cervical plexus, the second and third or some-

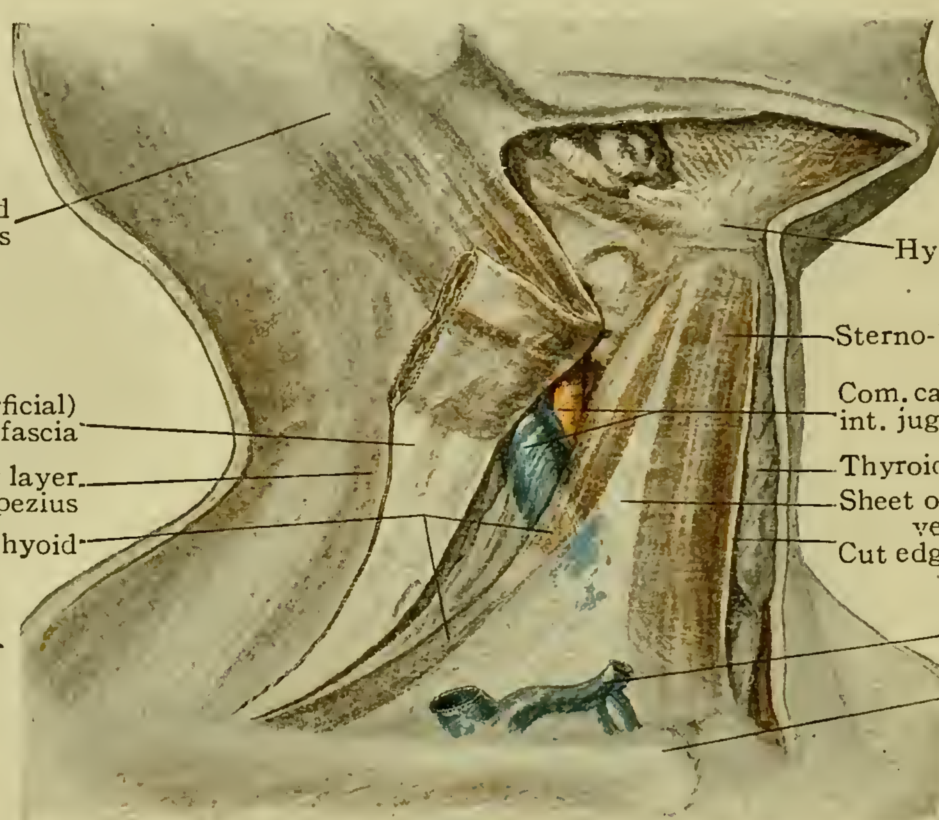

Fig. 177.—Deep cervical fascia, the superficial or investing layer reflected with the sterno-mastoid to show its relation to the latter and to expose the layer which invests the hyoid depressors.

times the third and fourth cervical nerves at the posterior border of the sterno-mastoid, the deep fascia necessarily being incised to expose the nerve. Traced upward, this nerve is seen to send a *mastoid branch* to the skin back of the ear, the trunk of the nerve continuing in front of the ear and giving *auricular branches* to the auricle and *facial branches* to the skin of the parotid region. So much of the nerve as lies upon the face will be worked out in the dissection of that region (Fig. 178).

The **occipitalis minor nerve** should be picked up and followed downward to its origin in the superficial cervical plexus (the second and third cervical nerves), the deep fascia being incised as much as may be necessary for the purpose. This nerve is sometimes very small and may be difficult to find. Passing upward along the posterior border of the

sterno-mastoid it distributes *cervical* branches to the skin of the neck, an *auricular* branch to the posterior surface of the auricle, and *mastoid* and *occipital* branches to the skin over the mastoid and the occipital region of the scalp respectively.

The **superficial cervical nerve** may be traced back to its origin from the second and third cervical nerves in the same way and should be followed to its termination near the mid-line of the neck (*lower branches*) and near the lower border of the lower jaw (*upper branches*) where it communicates with the inframandibular branch of the facial nerve as stated above.

The superficial descending branches of the cervical plexus, the terminal parts of which have been previously encountered, include the **suprasternal branch** or branches, the **supraclavicular** and the **supra-acromial;** these three branches respectively traced upward from their terminations are seen to come from a common trunk which is traceable to the third and fourth cervical nerves. Traced downward these nerves are seen to be distributed to the skin of the regions indicated by their names. It will now be seen that the superficial branches of the cervical plexus just named radiate from a common point of origin (Fig. 178) which corresponds approximately to the middle of the posterior border of the sterno-mastoid muscle.

The **great occipital nerve** (n. occipitalis major) perforates the deep fascia at the upper posterior angle of the posterior triangle close to the border of the trapezius, or sometimes external to this point (p. 317), in which case it perforates the trapezius also (Fig. 176). This nerve should be sought and isolated at its exit through the deep fascia. In close relation with it will be found the **occipital artery** which also perforates the fascia in this vicinity and which may serve as a guide to the location of the nerve.

A longitudinal incision may now be made over the middle of the sterno-mastoid muscle from its insertion downward to its origin, with due regard for the nerves that may be in the path of the incision. The deep fascia should be raised from the surface of the muscle and dissected toward either border of this structure, when the muscle itself may be raised from the underlying deep fascia by gentle manipulation with the fingers and blunt dissector. This will demonstrate the enclosure of the sterno-mastoid between two layers of the deep fascia, as well as the blending of these layers into one in front of and behind the position of the muscle (Fig. 177).

A median incision through the deep fascia should now be made from the chin to the suprasternal notch and the fascia should be raised from the mid-line toward the lateral aspect of the neck by the use of the fingers and the blunt dissector, when it may be demonstrated that a process of deep fascia is given off from the deep surface of this superficial layer

to enclose the omo-hyoid muscle and another to assist in forming the sheath of the carotid artery and the internal jugular vein (Fig. 177). By insinuating the fingers under the superficial layer of the deep fascia and passing them upward toward the hyoid bone and the mandible, the attachment of this layer to these two bony structures may be demonstrated. The deeper processes of the fascia will be further demonstrated at later stages of the dissection.

STERNO-CLEIDO-MASTOIDEUS (Fig. 178).—**Origin,** by an *inner* or *sternal head* from the first piece of the sternum, and an *outer* or *clavicular head* from the sternal head of the clavicle; between these two heads there is a distinct and variable interval. **Insertion,** the mastoid process of the temporal bone and the outer part of the superior nuchal line of the occipital bone. **Nerve-supply,** the spinal portion of the spinal accessory nerve, which passes obliquely through the muscle and the second and third cervical nerves. **Action,** to draw the back part of the head toward the sternum and so turn the face to the opposite side and somewhat upward. Both muscles acting together draw the mastoid and occipital regions downward. A variation of this muscle is shown in Fig. 179.

Spasmodic contraction of the sterno-cleido-mastoid due to irritation of its nerve constitutes **spasmodic wry neck** or **torticollis.** The scar resulting from partial rupture of this muscle during birth is also sometimes a cause of wry neck.

The **posterior triangle of the neck** is bounded in front by the sterno-mastoid, below by the clavicle, and behind by the anterior border of the trapezius. As it appears at this stage of the dissection it is covered by the superficial layer of the deep cervical fascia which has been partly incised in the preceding steps to expose the superficial branches of the cervical plexus. In the lower part of the space the dissector will come upon the posterior belly of the omo-hyoid muscle, which divides this triangle into the larger upper **occipital triangle,** and the smaller lower **subclavian triangle** (Fig. 178).

THE OMO-HYOID MUSCLE (m. omo-hyoideus) (Fig. 182). — **Origin,** the superior border of the scapula internal to the suprascapular notch, and from the transverse ligament. **Insertion,** the body of the hyoid bone, the muscle being subdivided into two bellies by an intervening tendon. **Nerve-supply,** the first, second and third cervical nerves through the ansa hypoglossi; **action,** to depress the hyoid bone and also pull forward the sheath of the carotid vessels through the attachment of the slip of fascia which invests its tendon to the sheath of those vessels.

The dissection of only the posterior belly need concern the dissector at present.

THE OCCIPITAL TRIANGLE.—**Boundaries:** behind, the anterior border of the trapezius; in front, the sterno-mastoid muscle; below, the posterior belly of the omo-hyoid. **Contents:** at the upper posterior angle sometimes a part of the great occipital nerve and a portion of the occipital

artery (p. 351); the small occipital nerve along the anterior border, parts of the great auricular, superficial cervical and superficial descending branches of the cervical plexus; the spinal accessory nerve; the dorsal scapular nerve; muscular branches from the cervical plexus to the trapezius, the posterior and middle scalene muscles; parts of the suprascapular and posterior thoracic nerves; in the lower portion of the space, part of the transversalis colli artery; a chain of lymph-nodes along the

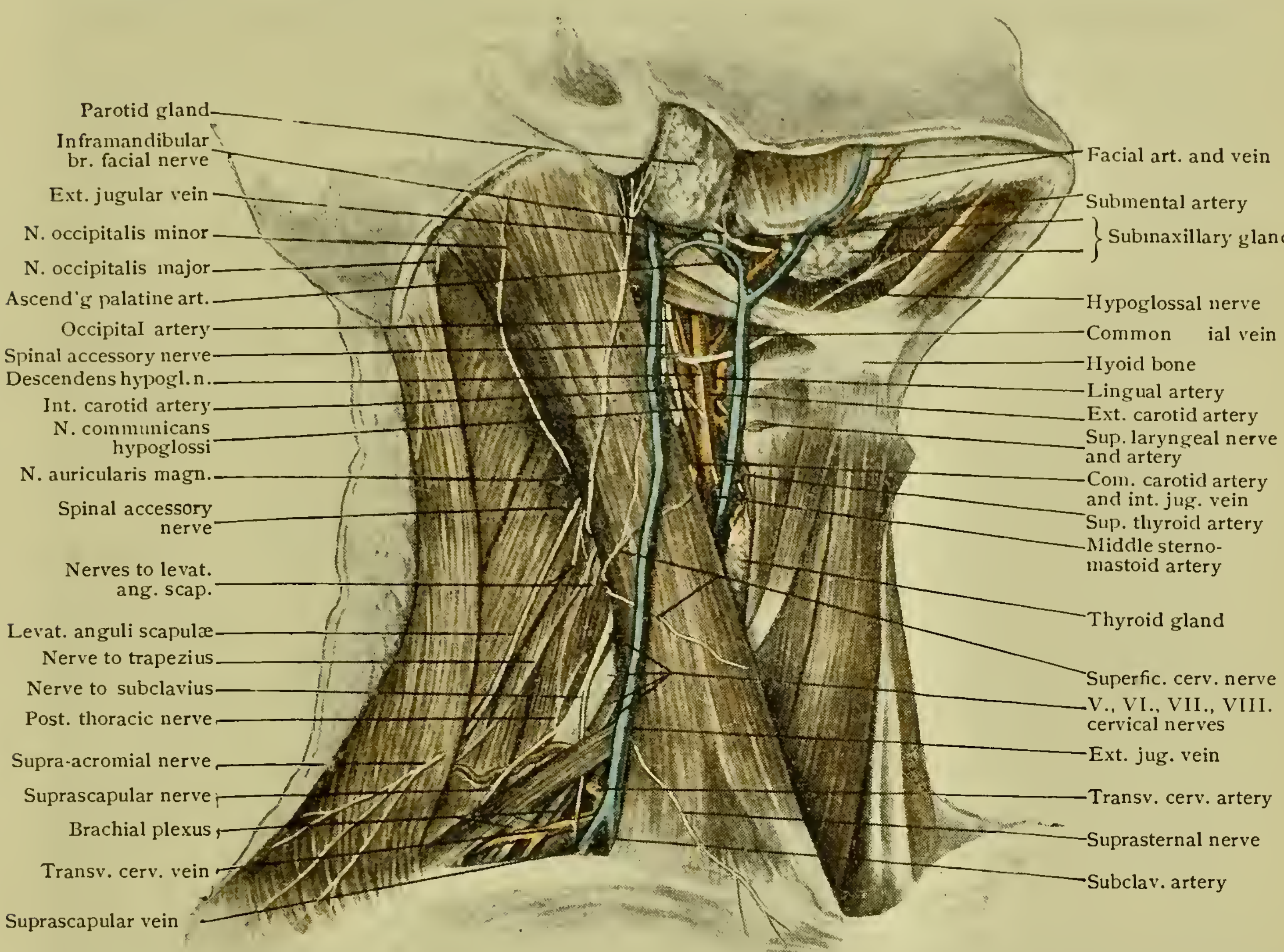

FIG. 178.—Dissection of antero-lateral region of neck, showing triangles and their contents.

posterior border of the sterno-mastoid muscle as well as a few nodes along the anterior border of the upper part of the trapezius.

The dissection of this space may be begun by following any one of the nerves already isolated to the middle of the posterior border of the sterno-mastoid. At about this point the **spinal accessory nerve** (p. 368) emerges from the sterno-mastoid muscle, the substance of which it traverses, to pass downward and outward across the posterior triangle to the border of the trapezius (Fig. 178) under which it disappears to enter the substance of that muscle. The nerve may be identified by the fact that when pulled upon, its course through the sterno-mastoid is

from above downward and superficially, he will find a small nerve, the **muscular branch to the subclavius muscle.** Passing from about the middle of the anterior boundary of the triangle outward and then curving downward toward the middle of the clavicle, he will find the **third portion of the subclavian artery.** This should be carefully cleaned. In about half the number of cases there will be no branches from this portion of the subclavian artery; in the other half there will be given off here the **posterior scapular artery,** a rather large vessel which passes

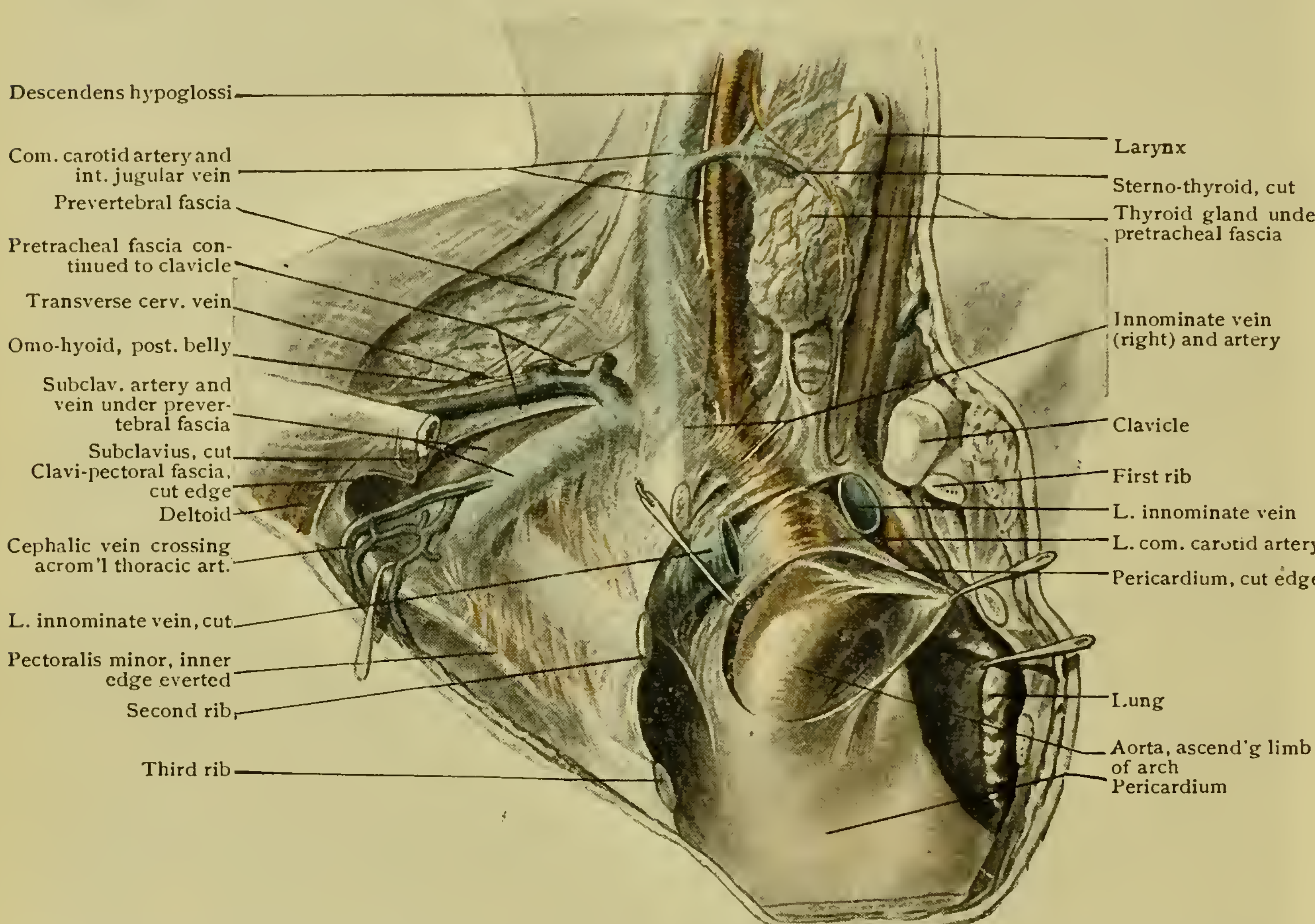

FIG. 180.—Deep cervical fascia, pretracheal and prevertebral layers. Sternum and part of right clavicle have been removed, a part of left innominate vein excised and an opening made in the pericardium. The continuity of the prevertebral fascia with the clavi-pectoral fascia on the deep surface of the lesser pectoral muscle is shown.

outward under the omo-hyoid to reach the occipital triangle. Passing across the upper anterior angle of the space will be found the **transverse cervical artery** on its way to the occipital triangle. Below the subclavian artery and, in fact, under cover of the clavicle and therefore not, strictly speaking, within the space, is the **suprascapular artery.** Immediately below the subclavian artery is the **subclavian vein,** a larger vessel than the artery. To the outer side of the subclavian artery will be found the trunks of the **brachial plexus** which should be carefully cleared of connective tissue, the dissector meanwhile noting carefully any branches that arise from these trunks.

Having worked out the foregoing structures the **floor** of the space may be considered, which is constituted by the posterior and middle scalene muscles and the first serration of the serratus magnus (Fig. 228). Now displace inward the posterior border of the sterno-mastoid muscle, retaining it in position with the retractor or hook. The deep fascia in this situation, the prevertebral (see p. 364), being carefully dissected up will disclose a nerve, the **phrenic,** the motor nerve of the diaphragm (Fig. 181), which corresponds in position to the posterior border of the undisturbed sterno-mastoid muscle. Dissect the phrenic, following it

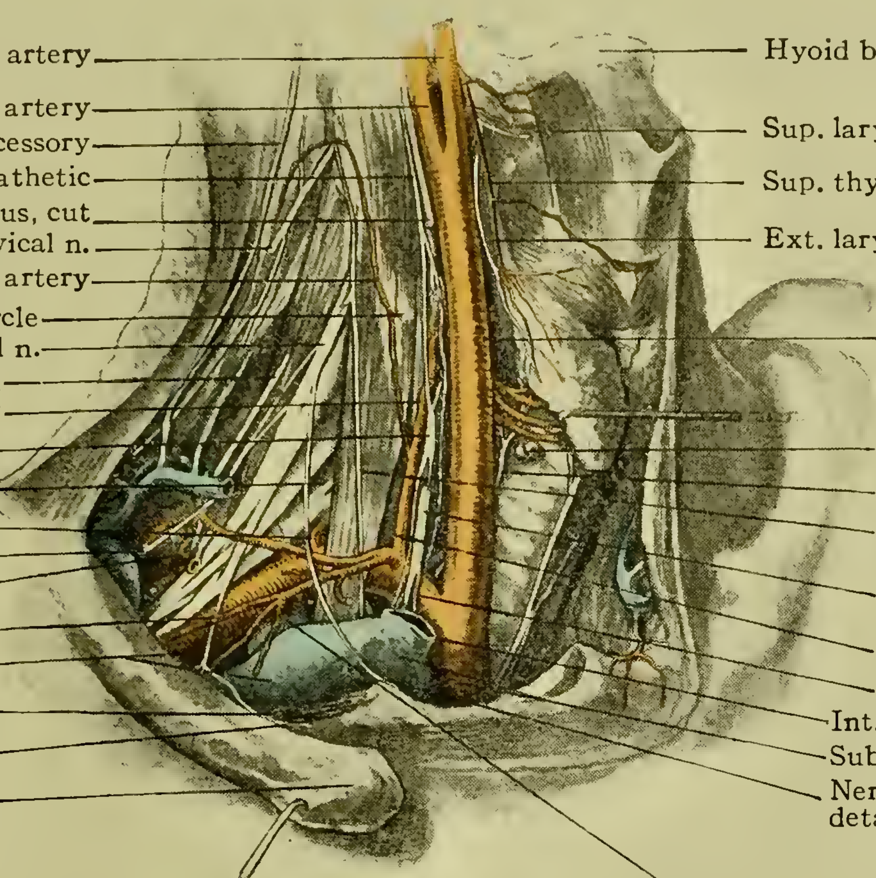

FIG. 181.—Deep dissection of neck. The clavicle has been detached from the sternum and displaced downward.

upward to its origin by two or three strands from the fourth, fifth and sixth cervical nerves respectively; traced downward the nerve will be found to cross superficially the subclavian artery to enter the thorax. The muscle upon which the phrenic nerve lies is the **anterior scalene** (p. 367). This should be cleaned from its attachments upon the third, fourth and fifth anterior tubercles of the transverse processes of the cervical vertebræ to its attachment to the outer surface of the first rib. Elevating the outer edge of the muscle will disclose the beginnings of the corresponding **cervical nerves** which go to form the **brachial plexus,** which should be cleared of connective tissue. When they have been cleaned they will be seen to lie upon the surface of the **middle scalene muscle.** The nerve to the anterior scalene and also that to the middle

from above downward and superficially, he will find a small nerve, the **muscular branch to the subclavius muscle.** Passing from about the middle of the anterior boundary of the triangle outward and then curving downward toward the middle of the clavicle, he will find the **third portion of the subclavian artery.** This should be carefully cleaned. In about half the number of cases there will be no branches from this portion of the subclavian artery; in the other half there will be given off here the **posterior scapular artery,** a rather large vessel which passes

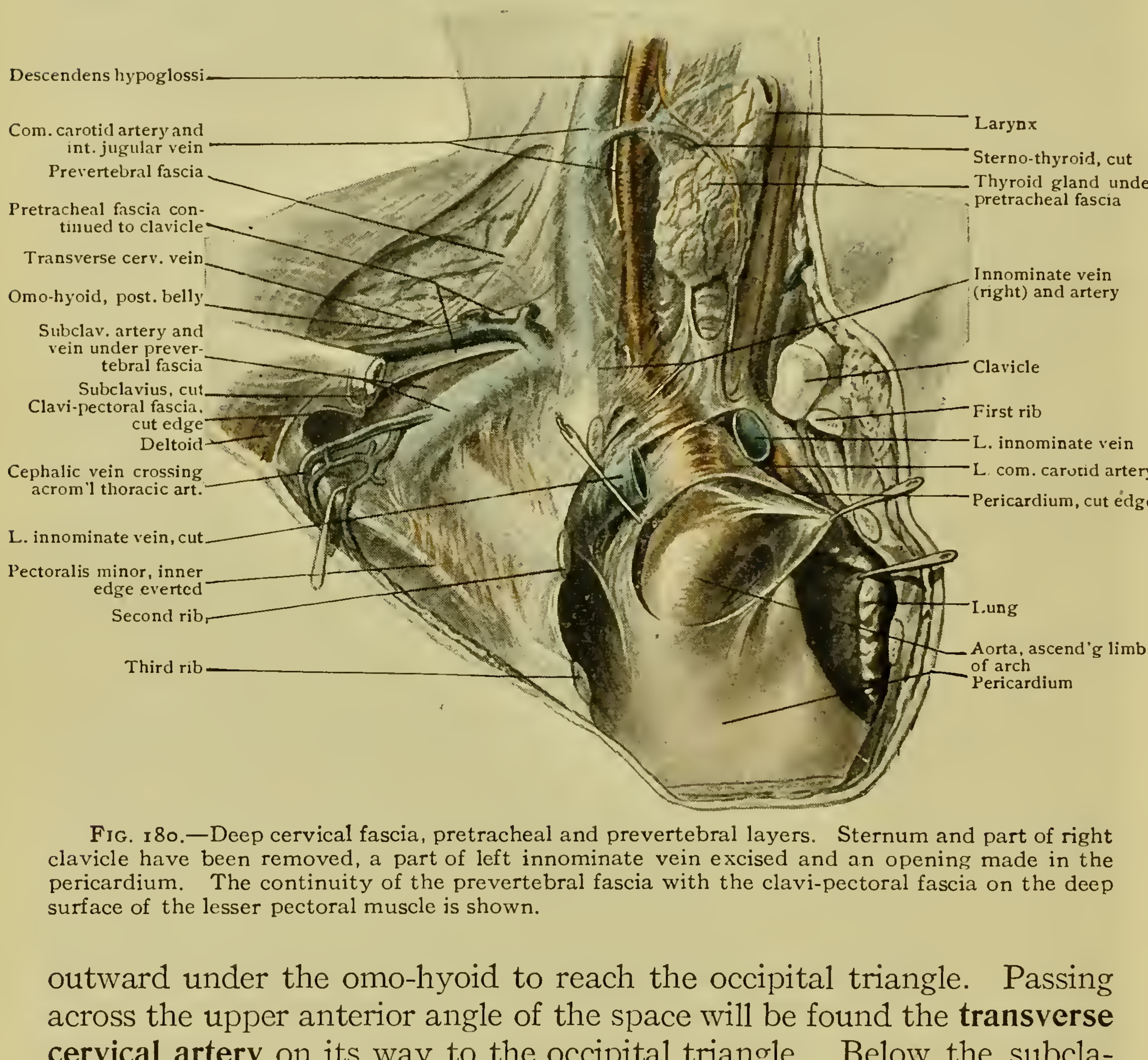

FIG. 180.—Deep cervical fascia, pretracheal and prevertebral layers. Sternum and part of right clavicle have been removed, a part of left innominate vein excised and an opening made in the pericardium. The continuity of the prevertebral fascia with the clavi-pectoral fascia on the deep surface of the lesser pectoral muscle is shown.

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Having worked out the foregoing structures the **floor** of the space may be considered, which is constituted by the posterior and middle scalene muscles and the first serration of the serratus magnus (Fig. 228). Now displace inward the posterior border of the sterno-mastoid muscle, retaining it in position with the retractor or hook. The deep fascia in this situation, the prevertebral (see p. 364), being carefully dissected up will disclose a nerve, the **phrenic,** the motor nerve of the diaphragm (Fig. 181), which corresponds in position to the posterior border of the undisturbed sterno-mastoid muscle. Dissect the phrenic, following it

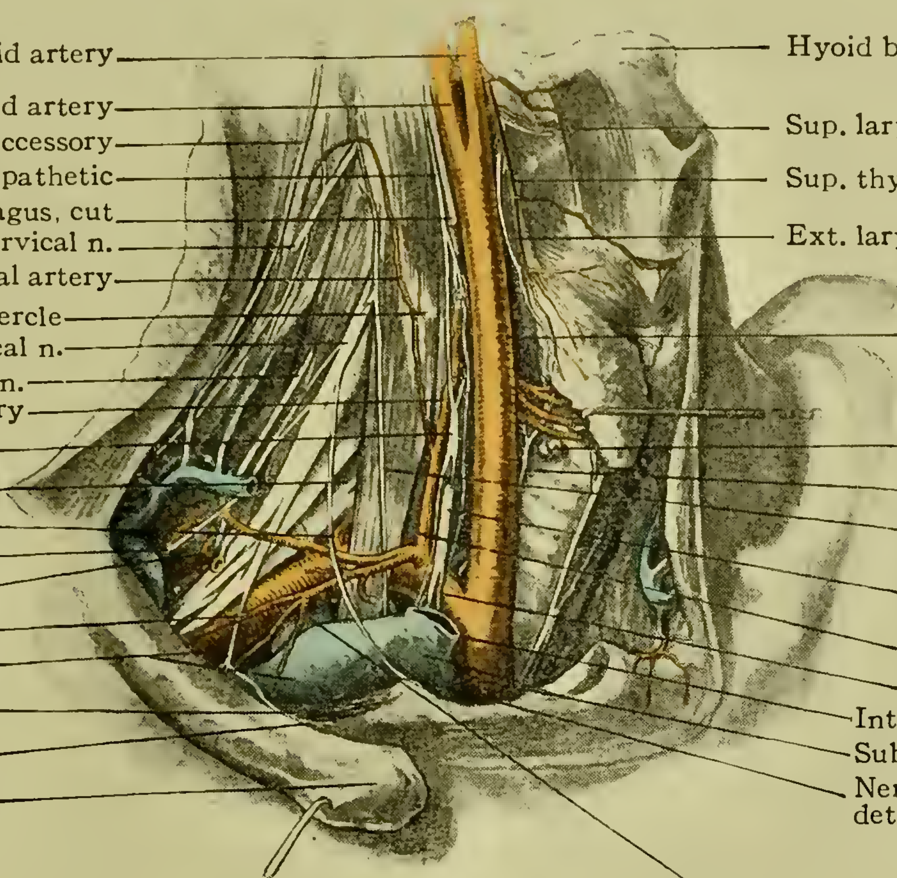

FIG. 181.—Deep dissection of neck. The clavicle has been detached from the sternum and displaced downward.

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scalene are branches of the cervical plexus. They enter the muscles on the surface adjacent to the plexus in each case. Having completed the dissection of this space the student should now proceed to study the relations of the contained structures, which relations have been in great measure pointed out above.

The Brachial Plexus (Fig. 29).—The brachial plexus is formed by the fifth, sixth, seventh and eighth cervical nerves and the first thoracic nerve. The fifth and sixth cervical nerves unite to form the **upper** or **outer trunk** of the plexus, the seventh constitutes the **middle trunk** and the eighth cervical and first thoracic unite to form the **lower** or **inner trunk.** These trunks lie upon the middle scalene muscle and are covered by the anterior scalene muscle. Each **trunk** divides into an *anterior* and a *posterior division* (Fig. 29). The anterior divisions of the upper and middle trunks unite to form the **outer cord** of the plexus, the posterior divisions of all three unite to form the **posterior cord,** while the anterior division of the lower trunk constitutes the **inner cord.** The plexus thus constituted, after leaving the space between the scalene muscles, lies in the outer part of the subclavian triangle to the outer side of the third portion of the subclavian artery and then passes beneath the clavicle, lying upon the first serration of the serratus magnus, to enter the axilla. The **branches** *above the clavicle* are the nerves to the scalenes, to the longus colli, to the subclavius, the posterior thoracic nerve and the suprascapular nerve. The **posterior thoracic nerve** (p. 44) emerges from the outer border of the middle scalene muscle, having been formed within the substance of this muscle by the union of a branch from the fifth nerve with a branch from the sixth. Passing to the outer side of the plexus it enters the axilla through its apex, sustaining the same relations as the plexus. The **suprascapular** nerve (p. 24) coming from the seventh cervical, passes outward toward the point of origin of the omohyoid, then through the suprascapular notch into the supraspinous fossa of the scapula to be distributed as indicated on page 25.

The **third portion of the subclavian artery** is that part of the vessel which is external to the anterior scalene muscle. It lies a variable distance above the clavicle, usually from one half to three fourths of an inch, passing from the middle of the anterior border of the triangle to the outer part of the lower border, becoming the axillary artery at the outer border of the first rib. Its relations, already indicated, are, upon the outer side, the brachial plexus; below, the subclavian vein and suprascapular artery; superficially, the termination of the external jugular vein and a superficial plexus of veins, while behind, it is in relation with the subclavian groove on the first rib.

The point of election for ligation of the subclavian artery is this third portion by reason of its greater accessibility as compared with the first and second portions and by reason of its giving off no branches in many cases or only one branch, the pos-

terior scapular (see above). By reason of its relation to the first rib it may be compressed here in order to control its circulation in operations such as amputation at the shoulder-joint. For the formation of the collateral circulation after ligation of the third portion of the subclavian see p. 53.

The **anterior triangle of the neck,** the region anterior to the sterno-mastoid muscle, is bounded in front by the median line, while the upper boundary is constituted by the lower border of the mandible and the line prolonged from its angle to the mastoid process. The anterior belly of the omo-hyoid, showing through its investing fascia, cuts off from this space the lower *inferior carotid* or *muscular triangle,* while the space above the omo-hyoid is subdivided into a lower space, the *superior carotid triangle,* and an upper, the *submaxillary triangle,* by the posterior belly of the digastric muscle (Fig. 178).

THE INFERIOR CAROTID TRIANGLE (the Triangle of Election or the Muscular Triangle).—**Boundaries:** in front, the median line of the neck; behind, the sterno-cleido-mastoid muscle; above, the anterior belly of the omo-hyoid. The **contents** of this space will be pointed out in the order of their dissection. The sterno-mastoid may now be divided transversely near its lower extremity and reflected outward and upward with that portion of the superficial layer of the deep cervical fascia which extends from the sterno-mastoid to the median line of the neck (Fig. 177). The reflection of this part of the superficial layer of the deep fascia exposes several muscles near the mid-line as well as the thyroid gland, and more laterally exposes the omo-hyoid muscle and its tendon and the sheath of the carotid vessels (Fig. 177). Carefully elevating the outer border of the omo-hyoid near its central tendon, the dissector may demonstrate the slip of fascia which passes from the sheath of the omo-hyoid to be connected with the sheath of the vessels and with the cartilage of the first rib.

From this arrangement of the omo-hyoid and its fascial connections, it will be seen that the contraction of the muscle, pulling upon the fascia which extends from it to the cartilage of the first rib, will, at the same time, pull upon the slip of fascia which attaches to the sheath of the vessels, drawing it forward and so tending to keep the internal jugular vein patulous.

The anterior belly of the omo-hyoid should now be cleaned from its central tendon to its insertion into the hyoid bone, in doing which the nerve to the anterior belly of the muscle will be found entering its superficial aspect; this nerve, traced upward and outward, will lead to the **ansa hypoglossi,** the loop of communication between the descendens hypoglossi and the communicans hypoglossi. The **descendens hypoglossi,** a slender nerve, should now be isolated as it lies upon the front of the sheath of the vessels and traced upward to its source in the hypoglossal nerve just as that nerve is arching across the external carotid artery. The **communicans hypoglossi** should also be traced from its

connection with the descendens upward and outward to its source in the second and third cervical nerves. The other **branches** of the ansa hypoglossi are a branch to the posterior belly of the omo-hyoid, a branch to the sterno-hyoid, and one to the sterno-thyroid (Fig. 182).

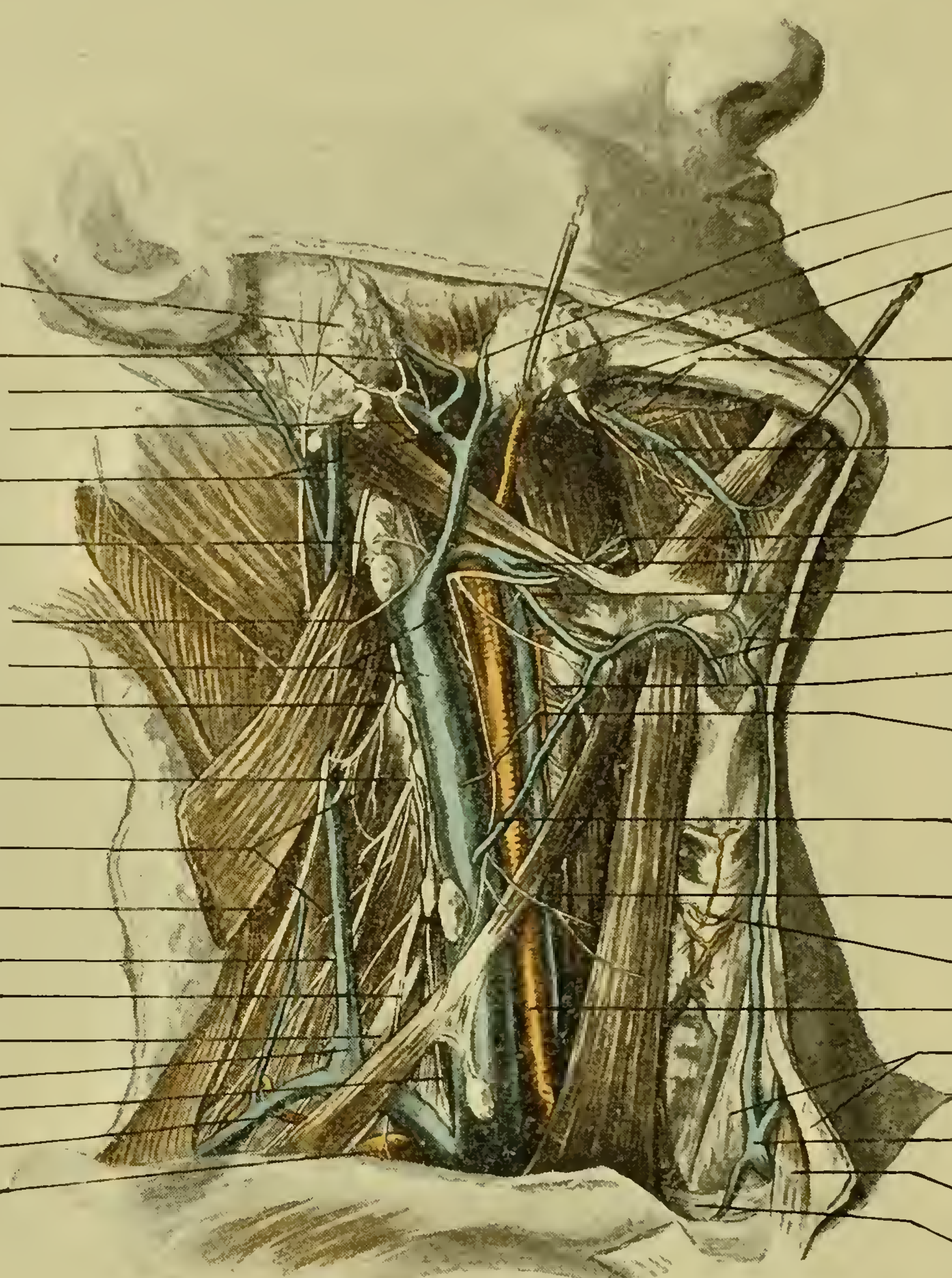

FIG. 182.—Dissection of neck. The submaxillary gland has been pulled upward and the sterno-cleido-mastoid detached below and reflected. The external jugular vein, after receiving the transverse cervical vein, terminates in the internal jugular. A chain of lymph-nodes is shown along the internal jugular vein. The sterno-hyoid and omo-hyoid muscles are seen passing up to the hyoid bone.

Although the hypoglossal nerve, the parent trunk of the descendens, is a cranial nerve, it communicates with the upper cervical nerves, and it is these filaments which it receives from the upper cervical nerves that pass through the communicans to supply the muscles named above; their nerve-supply is, therefore, from the cervical nerves and not from a true cranial nerve.

THE STERNO-HYOID MUSCLE (Fig. 182).—**Origin,** from the first piece of the sternum and the sternal end of the clavicle; **insertion,** the

hyoid bone; **nerve-supply,** the ansa hypoglossi; **action,** to depress the hyoid bone. This muscle should be cleaned from its origin to its insertion and will be seen to be of delicate texture. Its investing sheath of deep fascia must, therefore, be removed with care. When the muscle has been isolated the inner border may be raised cautiously and carefully drawn to one side, exposing the underlying sterno-thyroid; or the sterno-hyoid may be divided near its insertion and reflected.

The Sterno-Thyroid Muscle (Fig. 178).—**Origin,** the first piece of the sternum and the cartilage of the first and sometimes of the second rib; **insertion,** the oblique line of the thyroid cartilage; **nerve-supply,** from the ansa hypoglossi; **action,** to assist in depressing the hyoid bone. This muscle should be cleaned from its origin to its insertion and should then be elevated from the thyroid gland, which lies beneath it.

The Thyro-Hyoid Muscle (Fig. 178).—**Origin,** the oblique line of the thyroid cartilage; **insertion,** the body and great horn of the hyoid bone; **nerve-supply,** the hypoglossal nerve; **action,** to depress the hyoid bone.

The Middle or Pretracheal Layer of the Cervical Fascia.—With the completion of the foregoing processes the dissector will have exposed the second or middle layer of the deep cervical fascia. This layer splits off from the superficial layer in a line corresponding to the deep aspect of the sterno-mastoid muscle, which may be demonstrated by passing the fingers under this muscle (page 352) or by reflecting the latter in its sheath. Traced inward, the pretracheal fascia is seen to be attached to the body and the great horn of the hyoid bone; above this bone it blends with the superficial layer. Traced downward from the hyoid bone, the fascia passes in front of the larynx and trachea, investing the thyroid gland in a thin sheath and continuing downward in front of the trachea it passes into the thorax to become continuous with the fibrous layer of the pericardium (Fig. 180). Traced laterally, the precervical fascia is seen to be attached below to the deep border of the clavicle.

The relation of the cervical fascia to the pericardium is significant in view of the fact that during the early stages of development the heart is in the cervical region.

The Thyroid Gland.—This structure consists of two **lateral lobes** lying one on either side of the trachea and the connecting **isthmus,** which crosses the trachea opposite the second or the second and third rings. Upon the isthmus is a plexus of veins which should now be dissected, and emerging from the gland laterally are the **superior** and **middle thyroid veins,** which vessels should be traced to their *termination* in the internal jugular vein. Passing downward from the gland in front of the trachea are the **inferior thyroid veins** (Fig. 183) which should be followed as far toward their *termination* in the innominate vein as possible. In dissecting the inferior thyroid veins, one may find along the

median line of the trachea a small artery, the **thyroidea ima** or **infima,** a branch of the innominate artery. It is only occasionally present. The **blood-supply** of the gland is from the superior thyroid artery, which enters the upper lateral portion of the gland and which need be dissected now only for about one half inch from the gland, and the inferior thyroid artery which enters the gland low on its lateral aspect and which should be dissected only partially at this time.

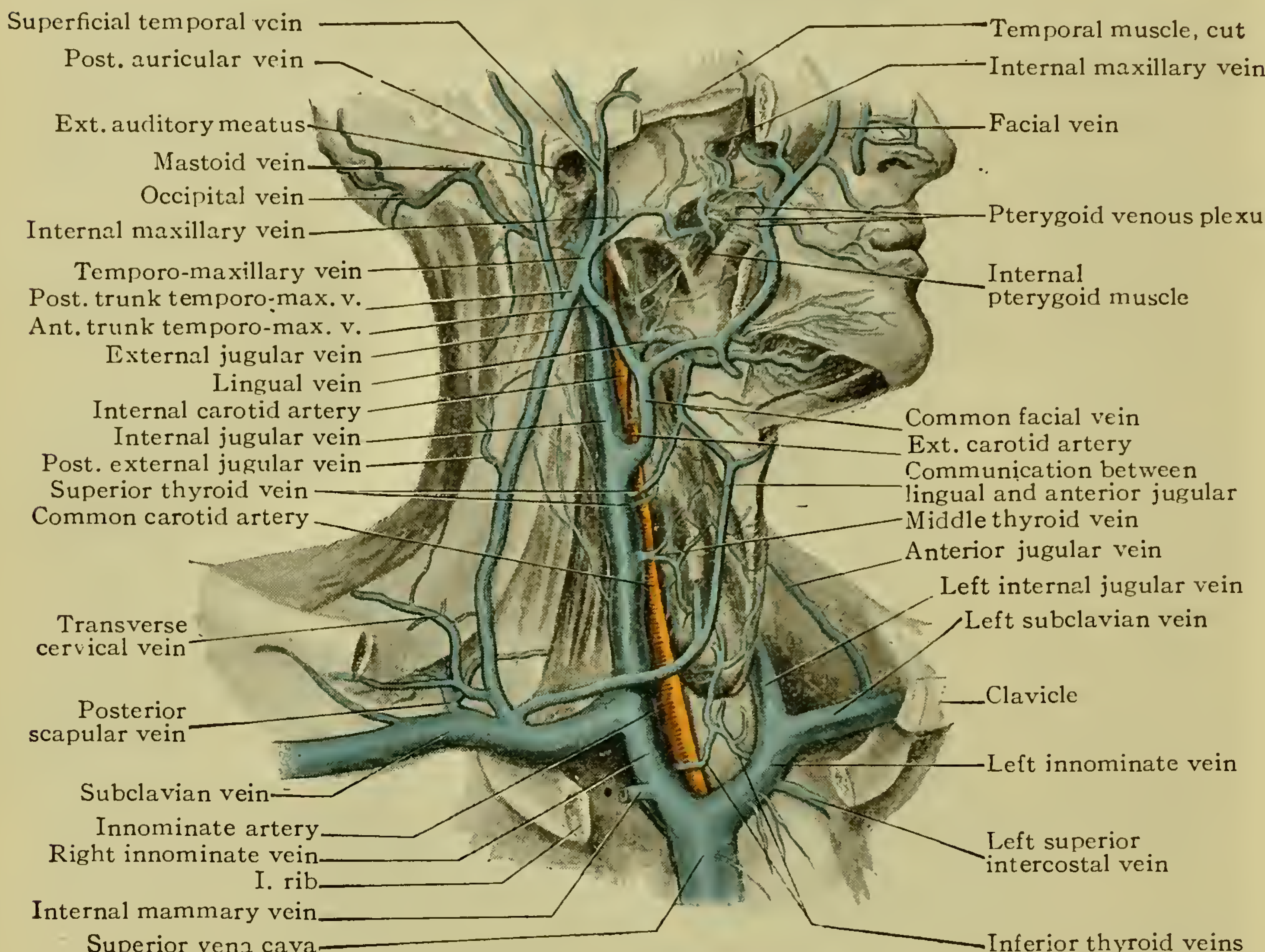

FIG. 183.—Dissection showing deep veins of neck and head.

The close relation of the thyroid gland to the trachea is of importance, first, in connection with the various enlargements of the gland, as in the several varieties of *goitre*, when the enlarged structure may cause difficulty in breathing by pressure upon the trachea; and, second, in connection with the *operation of tracheotomy* or cutting into the wind-pipe to relieve the dyspnœa of laryngeal diphtheria or that due to the presence of a foreign body in the larynx. *Tracheotomy* may be performed above the isthmus of the gland or below it; or it may be necessary to divide the isthmus. In either case the veins on the surface of the thyroid may be the source of troublesome hemorrhage which, however, is serious only in so far as it prolongs the operation or, by reason of the entrance of blood into the tracheal wound, causes either further embarrassment of respiration or inspiration pneumonia. The free blood-supply of the gland renders *thyroidectomy* or removal of the gland an extremely bloody and serious operation.

The Trachea.—The trachea, beginning at the cricoid cartilage opposite the sixth cervical vertebra, passes down to the level of the fourth thoracic vertebra, where it divides into the two bronchi. Note that as it passes downward it gradually assumes a deeper position and hence is more accessible for operation in the upper part of its course. Its relations to the thyroid gland and its veins were indicated above. Gently raising the trachea and displacing it to one side shows the œsophagus as a collapsed tube lying behind it. Latero-posteriorly it is in close relation with the recurrent or inferior laryngeal nerve and in less close relation with the great vessels of the neck. At the root of the neck it is crossed by the innominate artery, which crosses at a higher level in the infant than the adult.

This relation of the innominate artery constitutes an added disadvantage of the low operation of tracheotomy.

The *blood-supply* of the trachea is from the inferior thyroid artery chiefly, and also from the superior thyroid; its *nerve-supply* is from the recurrent laryngeal nerve. For further dissection of the trachea, see Chapter IV.

The Larynx. — The lower and smaller cartilage of the larynx, the **cricoid cartilage,** is connected with the trachea by the crico-tracheal membrane; the upper border of this cartilage is connected with the upper and larger **thyroid cartilage** by the crico-thyroid membrane. The **crico-thyroid muscle** (Fig. 181), arising from the cricoid cartilage and extending upward and outward to the thyroid cartilage, partly covers this membrane. In cleaning the surface of this muscle try to discover its nerve of supply, the *external laryngeal branch* of the superior laryngeal nerve, which enters its superficial surface from above and inward; trace the nerve upward to the **superior laryngeal nerve** (Fig. 181). The **crico-thyroid space** corresponds with that portion of the crico-thyroid membrane which is between the two crico-thyroid muscles. It is crossed transversely by a small artery, the crico-thyroid, from the superior thyroid.

Laryngotomy, or cutting into the larynx, is performed in this space, the incision through the membrane being transverse, although the superficial skin incision is a vertical one.

The **thyro-hyoid membrane** (Fig. 184), connecting the upper border of the thyroid cartilage with the hyoid bone, should now be cleaned and it should be noted that it is perforated laterally by a nerve and an artery, the **internal laryngeal nerve** from the superior laryngeal branch of the vagus, and the **superior laryngeal artery** from the superior thyroid artery. Isolate these for a short distance from the larynx. The dissection of the interior of the larynx is to be deferred until its removal from its connections.

The sterno-cleido-mastoid muscle should now be reflected upward and outward to expose the structures at the root of the neck.

The **common carotid artery** and the **internal jugular vein** enclosed in their sheath may be gently elevated with the tips of the fingers and a blunt dissector, when it will be seen that the posterior wall of the sheath is attached to a deeper layer of fascia. This is the **prevertebral layer** of the cervical fascia. The separation of the sheath of the vessels may be continued upward to the bifurcation of the common carotid artery at the level of the upper border of the thyroid cartilage.

The **prevertebral layer** of the deep cervical fascia is thus partially exposed in the lower part of the neck. The upper part of this layer will be seen after the dissection of the structures higher up. This fascia is attached above to the under surface of the basilar process of the occipital bone and passing downward from this point lies in front of the prevertebral muscles, *i.e.*, the longus colli and the anterior straight muscles (Fig. 228), and continues downward between these muscles and the œsophagus into the thorax. Before reaching the œsophagus it lies between the muscles named and the pharynx, being separated from the pharynx by areolar tissue which occupies what is known as the *retropharyngeal space.* Laterally, the prevertebral fascia passes over the anterior scalene muscle and the trunks of the brachial plexus and the subclavian artery and vein as shown above (p. 355), and continues downward into the axillary space where it becomes attached to the deep surface of the clavi-pectoral fascia.

The **sheath of the vessels** will be seen to be crossed by the omo-hyoid and in the neighborhood of this muscle, usually above it, will be found a small artery—the **superficial descending** or **middle sterno-mastoid branch** of the superior thyroid, which crosses the sheath obliquely downward and outward. The descendens hypoglossi should be pulled aside preparatory to opening the sheath.

Beginning at the root of the neck again the sheath of the vessels may be opened by raising the anterior wall of the sheath with the forceps and incising it, when the **pneumogastric nerve** will be found lying between the artery and the vein, and on a deeper plane than either. The nerve should be raised gently so as not to tear its branches. The **branches** in this part of the neck are the *middle* and *inferior cervical cardiac branches*, one of which may be absent. From this point the trunk of the nerve being gently raised should be traced downward to the point where it crosses the subclavian artery to enter the thorax on the right side of the neck or, if the left side is the seat of operation, the nerve enters the thorax by the side of the left subclavian artery. The *cardiac branches* of the nerve pass downward and may cross the subclavian artery or may pass beneath it to enter the thorax. Tracing the nerve upward it will be found at the bifurcation of the common carotid artery to follow the

internal carotid toward the base of the skull. In thus tracing the nerve upward the *superior cervical cardiac branch* may be encountered, which may run within the sheath of the vessels and may be joined below by the *middle* or the *inferior cardiac branch* or by both; the superior *laryngeal branch* of the pneumogastric may also be found; these two nerves may, however, arise so high up that there will be difficulty in finding their points of origin at present. Where the right pneumogastric nerve crosses the subclavian artery it gives off its *recurrent* or *inferior laryngeal branch*, which encircles the subclavian artery from before backward (Fig. 186) to pass upward on the inner side of the common carotid artery to gain a position beneath the lateral portion of the trachea between it and the œsophagus on its way to the posterior aspect of the larynx. In order to dissect this nerve the trachea must be drawn well toward the mid-line of the neck. It may be necessary to defer the identification of this nerve at its origin until the work of the dissector of the upper extremity has reached such a stage as to permit of disarticulation of the sternal end of the clavicle.

The **common carotid artery** should now be divested of connective tissue, beginning at the **origin** of the vessel on the right side from the bifurcation of the innominate artery behind the sterno-clavicular articulation. The work of cleaning the vessel should progress upward to its **point of bifurcation** when the **external carotid** should be similarly followed upward now or later to the point where it enters the parotid gland. The common carotid gives off no branches except its *terminal branches*, the internal and external carotids.

The **internal jugular vein** should now be cleaned beginning at the root of the neck. Traced downward it will be seen to **terminate** by uniting with the subclavian vein. In the lower part of its course it presents an enlargement, the **gulf of the vein,** and traced upward it is found to receive as **tributaries** the *middle thyroid vein* or veins, the *superior thyroid vein* and still farther up the *lingual vein*, the *common facial vein* and the *anterior trunk of the temporo-maxillary vein* (Fig. 183). If fully distended these various tributaries are vessels of considerable size although they may appear very inconspicuous if empty. The internal jugular should be traced as far up as possible toward the base of the skull where it **originates** (p. 333) by the confluence of the inferior petrosal sinus and the lateral sinus.

The **gangliated cord of the sympathetic nerve** lies behind the sheath of the carotid vessels and consists of the *superior*, *middle* and *inferior* cervical ganglia connected by a nerve or nerve strands, the *association cords*. The association cord may be picked up and traced downward to the **middle** or **thyroid ganglion,** which is small and is situated in front of the inferior thyroid artery in close proximity to the sixth cervical transverse process behind the sheath of the vessels (Fig. 186). This

ganglion is connected by *rami communicantes* with the fifth and sixth cervical nerves and sends branches to accompany the inferior thyroid artery, besides giving off a *middle cervical cardiac branch* which may pass independently into the thorax or may join the above mentioned superior cardiac branch. From its lower angle the cord connecting it with the **inferior ganglion** may be followed downward to that ganglion, which is situated in front of the seventh cervical transverse process (Fig. 186). The latter ganglion is connected by *rami communicantes* with the seventh and eighth cervical nerves and gives off *branches* to accompany the vertebral artery and the *inferior cervical cardiac branch*, which may unite with the superior, the middle or with both cardiac branches to form a common trunk.

The **inferior thyroid artery,** a vessel of considerable size, is situated behind the sheath of the vessels at the lower part of the neck (Fig. 181). Arising from the thyroid axis of the subclavian, it ascends vertically for about an inch or more, then curves inward and downward toward the thyroid gland which it enters. The summit of its curve is just below or sometimes in front of the sixth cervical transverse process (the carotid tubercle). Followed from the point where it curves it will be found to give off a slender **branch,** the *ascending cervical artery*, which passes up in front of the transverse processes of the cervical vertebræ, and farther along it gives off an *inferior laryngeal branch* which passes upward to the larynx behind the trachea, which latter must be displaced inward to expose the vessel; still later it gives off *tracheal branches*. The **thyroid axis** and its other two **branches,** the *suprascapular* and the *transverse cervical*, may be dissected now or after the clavicle has been disarticulated from the sternum (p. 384).

The inferior thyroid artery is sometimes ligated in cases of *goitre* or *bronchocele*. The vessel may be reached through an incision above the clavicle along the anterior border of the sterno-mastoid muscle, the muscle and the sheath of the common carotid artery and internal jugular vein being displaced outward after the incision of the deep fascia. The carotid tubercle (p. 345) is the guide to the artery, the latter being just below the tubercle, with the carotid sheath on its outer side and the trachea and œsophagus on its inner side; the recurrent laryngeal nerve is sometimes quite close to its inner side or occasionally in front of it. The relation of the middle cervical ganglion (p. 365) and the course of the cervical cardiac branches of the sympathetic have been noted.

The **vertebral artery,** the largest branch of the subclavian, lies behind the sheath of the vessels or, more accurately, behind the internal jugular vein and the vertebral vein in a depressed triangular interval between the longus colli and anterior scalene muscles (Fig. 185). Cleaning the surface of this vessel and noting that it is crossed by the inferior thyroid artery, it should be traced downward to its origin in the first portion of the subclavian artery, where, on the left side of the body, the thoracic duct passes in front of it. Traced upward to the carotid tuber-

cle, which is a guide to the vessel, it is seen to enter the foramen of the transverse process of the sixth cervical vertebra, traversing which it passes successively through the foramina of all the cervical transverse processes above the sixth. Its course in this part of the neck and its branches will be dealt with later (p. 489); its intracranial course and branches will be worked out in dissecting the brain (p. 498).

The vertebral artery has been ligated in a few instances for hemorrhage and traumatism and also to diminish the blood-supply of the brain in epilepsy. If the student will replace the sterno-mastoid muscle in position, he will see that this artery may be reached for ligation by displacing the posterior border of the muscle forward and drawing forward and inward the sheath of the carotid vessels. (The posterior border of the muscle, therefore, and the carotid tubercle serve as surface guides to the position of the artery.) The operator, having gone through the deep cervical fascia, utilizes the carotid tubercle again and the muscular interval below it in which the artery lies as his guides to the location of the vessel.

A **cervical rib** may sometimes be found in this region of the neck, this being when present an over-development of the anterior portion of the transverse process of the seventh cervical vertebra, or very rarely of the sixth. This supernumerary rib may occur in the form of a fixed bony outgrowth or it may be movable.

Cervical ribs when *fixed* may be mistaken for exostoses or other forms of tumor; when *movable* or of sufficient length they sometimes lead to an erroneous diagnosis of aneurism, the subclavian artery usually passing over the rib, its pulsation, associated with the abnormal prominence or fulness, leading to the error in diagnosis. A cervical rib may also produce tingling or pain in the arm by irritation of the first thoracic nerve.

Scalenus Anticus (Fig. 181).—**Origin,** the third, fourth, fifth and sixth cervical vertebræ, the anterior tubercles of their transverse processes; **insertion,** the scalene tubercle on the upper surface of the first rib; **nerve-supply,** the third, fourth, fifth and sixth cervical nerves, anterior divisions; **action,** to elevate the rib and so assist in inspiration or to flex and rotate the cervical spine.

Although an occupant of this triangle, this muscle was dissected with the contents of the subclavian triangle in order to demonstrate its relations to the brachial plexus. Upon the inner side of it will be found the **longus colli muscle** (Fig. 185), which can be dissected more advantageously at a later stage of the work (p. 486).

The **inferior constrictor of the pharynx** at its origin upon the side of the cricoid cartilage and the oblique line of the thyroid cartilage lies within the inferior carotid triangle (Fig. 182). This portion of the muscle should not be cleaned as yet.

The **floor of the inferior carotid triangle** is now seen to be the longus colli and the scalenus anticus with a small portion of the rectus capitis anticus major above.

The first and second portions of the subclavian artery and the corresponding portions of the subclavian vein (p. 383) may be dealt with to best advantage when the dissector of the upper limb reaches such a stage of his work as to permit of the disarticulation of the clavicle from the sternum.

The dissection of the digastric and stylo-hyoid muscles should be undertaken now as a preliminary to the dissection of the superior carotid triangle.

The Digastric Muscle (Fig. 182).—**Origin,** the *posterior belly* from the digastric fossa on the mastoid process of the temporal bone; the *anterior belly* from the digastric fossa of the mandible. Its intervening tendon is bound down to the greater horn and body of the hyoid bone by a slip of fascia. The termination of the posterior belly perforates the stylo-hyoid muscle. **Action,** to elevate the hyoid bone and larynx and to assist in depressing the mandible. **Nerve-supply,** the anterior belly, the mylo-hyoid branch of the inferior dental nerve; the posterior belly, the digastric branch of the facial nerve.

Cutting through the superficial layer of the cervical fascia below the body of the mandible will disclose the posterior belly of this muscle which should now be denuded. In dissecting toward the central tendon which is bound down to the hyoid bone by a slip of fascia, work cautiously in order to preserve this slip and to avoid injury to the stylo-hyoid muscle. In exposing the anterior belly, a small layer of fascia with occasionally some muscular fibres will be found to unite the muscle of one side with that of the other just above the hyoid bone; this is the *suprahyoid aponeurosis.*

The Stylo-Hyoid Muscle (m. stylo-hyoideus).—**Origin,** the upper part of the styloid process of the temporal bone; **insertion,** the base of the great horn of the hyoid bone; **nerve-supply,** the digastric branch of the facial nerve; **action,** to elevate the hyoid bone. This muscle is of such delicate texture that its dissection must be done cautiously in order to avoid injury. Note its perforation by the posterior belly of the digastric.

Now replace the sterno-mastoid in position in order to demonstrate the boundaries of the superior carotid triangle.

The Superior Carotid Triangle or Triangle of Election (Fig. 178).—**Boundaries:** below and behind, the sterno-mastoid muscle; below and in front, the anterior belly of the omo-hyoid; above, the posterior belly of the digastric. Again reflecting the sterno-mastoid, the dissector should identify and isolate the **spinal accessory nerve** as it enters the deep surface of this muscle. The nerve will be found to pursue a course of several inches before entering the muscle, and is embedded in rather dense connective tissue which sometimes makes its recognition difficult. It may be traced upward as far as may be convenient at this stage of the dissection.

The **spinal accessory** or **eleventh cranial nerve** consists of a *spinal portion*, which originates in the cells of the ventral gray horns of the spinal cord from the sixth cervical segment to the first, the fibres passing upward beside the cord (Fig. 282) and entering the skull through the foramen magnum; and a *cerebral* or *accessory portion* which arises in the medulla in common with the vagus, of which it is really a part and which, after emerging from the medulla (Fig. 166), joins the spinal portion. The trunk thus constituted escapes from the skull through the jugular foramen and at once gives back its cerebral fibres to the vagus below the latter's lower ganglion, the remaining part of the nerve passing downward in the neck between the internal carotid artery and the internal jugular vein and then outward and downward beneath the vein to reach the deep surface of the sterno-mastoid (p. 368). Being the chief source of supply for this muscle, the nerve is sometimes resected for "*wry neck*" (p. 352) and may be reached for this purpose through an incision along the anterior border of the muscle near the lower end of its upper third.

The sheath of the common carotid has already been opened to the point of bifurcation of this vessel, as has the upward continuation of the sheath which encloses the internal carotid and the internal jugular vein. The **venous trunks** entering the latter vessel should now be dissected—the **lingual vein** and a little above it the **trunk** formed by the union of the *common facial vein* and the *anterior trunk of the temporo-maxillary vein* (Fig. 183) being the chief tributaries in this region.

The Common Carotid Artery.—The **course and relations of the common carotid artery** should now be considered. The **surface line** indicating its course is one drawn from the sterno-clavicular articulation to a point midway between the angle of the mandible and the mastoid process. With the sterno-mastoid *in situ* the artery is beneath the anterior border of this muscle. It is related most intimately with the internal jugular vein, which lies external to it within the same fascial sheath, and the pneumogastric nerve, also within the sheath, between the vein and artery and upon a deeper plane.

In front the sheath is overlapped by the sterno-mastoid muscle and to some extent by the sterno-hyoid and sterno-thyroid and has resting upon it the descendens hypoglossi nerve and the ansa hypoglossi (Fig. 182), being crossed at its upper part from above downward and outward by the middle sterno-mastoid branch of the superior thyroid artery, the superior and middle thyroid veins and the omo-hyoid muscle, and below by the anterior jugular vein.

Behind, the sheath is in immediate relation with the gangliated cord of the sympathetic and its branches, the longus colli muscle and the inferior thyroid artery, the vertebral artery being in proximity, behind the internal jugular vein; behind the lower part of the sheath is also the recurrent laryngeal nerve as it passes upward and inward.

Internal to the sheath the recurrent laryngeal nerve is found passing to the interval between the trachea and œsophagus on its way to enter the posterior aspect of the larynx. The terminal portion of the inferior thyroid artery will also be found in this region as well as the thyroid

gland, the larynx and the trachea. **Externally** the sheath is in relation with the phrenic nerve.

The **carotid body** should be sought upon the deep surface of the common carotid artery at its bifurcation. It is quite small, oval and brownish in color and may be mistaken for a lymph-node, but is to be recognized by reason of its connection with numerous nerve-fibres that come from those that interlace around the carotid arteries. This structure is one of the ductless glands.

The **parathyroid bodies** (Fig. 181) are to be found in relation, the *upper one* with the posterior aspect of the œsophagus opposite the lower border of the cricoid cartilage, the *lower one* with the side of the trachea and the deep surface of the thyroid gland below the inferior thyroid artery.

Since the common carotid artery is more accessible in the superior carotid triangle than in the inferior triangle, the former is called the triangle of election.

The common carotid artery may be but is not frequently the seat of aneurism, which occurs oftenest near the bifurcation of the vessel. Such an aneurism may be differentiated from enlargement of the thyroid gland by taking into consideration the fact that the thyroid gland will move upward and downward in the act of swallowing, whereas the aneurismal tumor will not, besides considering the usual aneurismal signs of *bruit*, pulsation, et cetera.

The *pressure-symptoms* of aneurism of the common carotid are to be interpreted by recalling the vessel's relations. Thus pressure on the internal jugular vein may cause cerebral hyperæmia with vertigo, visual disturbance and impaired mentality; on the vagus, cardiac and respiratory disturbance; on the phrenic, hiccough and dyspnœa; on the sympathetic, vasomotor disturbances and myosis or mydriasis; on the recurrent laryngeal nerve, laryngeal disturbances such as cough, loss of voice, hoarseness or dyspnœa; pressure on the œsophagus, dysphagia; pressure on cervical nerves or their branches, pain. In aneurism of the common carotid situated near the root of the neck, it is not desirable to tie the vessel on the proximal side of the aneurism (*proximal* or *Hunterian ligation*) on account of the danger of ligating the vessel so close to its origin, especially as the disease is not infrequently an extension of aneurism of the innominate artery, and therefore in such cases the *distal ligation* is resorted to. In performing the distal ligation, either the entire circulation on the distal side of the tumor is interrupted, as by the ligation of the common carotid itself or of both of its terminal branches (Wardrop's operation), or only a part of the distal circulation is obstructed, as by the ligation of the external carotid alone (Brasdor's operation).

The External Carotid Artery.—This vessel, one of the terminal branches of the common carotid, **arises** at the bifurcation of the latter opposite the upper border of the thyroid cartilage and passing upward and somewhat outward under the posterior belly of the digastric, enters the submaxillary triangle and a little later the parotid gland. Reaching a point between the neck of the condyle of the mandible and the external meatus, it **terminates** in two terminal branches, the *superficial temporal* and the *internal maxillary arteries*. Its **surface line** is one drawn from the side of the cricoid cartilage to the external meatus slightly convex forward. Its **relations** in the neck are, *in front*, the anterior border of

the sterno-mastoid, the lingual and facial veins, the hypoglossal nerve, and the digastric and stylo-hyoid; *behind*, the superior laryngeal and glossopharyngeal nerves, the stylo-glossus and stylo-pharyngeus muscles; *externally*, the internal carotid artery; *internally*, the pharynx and the superior laryngeal nerve.

The external carotid gives off five **branches** in the neck, which must be regarded in the dissection of the vessel. The **superior thyroid artery,** the first branch, should be followed downward and inward in its course toward the thyroid gland; its *branches* are the small *infra-hyoid branch*, which passes inward just below the great horn of the hyoid bone; the *superior laryngeal artery*, which passes inward to enter the larynx through the thyro-hyoid membrane accompanied by the superior laryngeal nerve; the *middle sterno-mastoid branch*, going downward and outward across the common carotid to enter the deep surface of the sterno-mastoid muscle; and the *crico-thyroid artery*, a small branch which communicates with its fellow of the other side across the crico-thyroid membrane.

The position of the superior thyroid artery renders it especially liable to injury in "cut throat" wounds.

The **superior laryngeal nerve,** the chief sensory nerve of the larynx, should now be picked up and traced to its point of entrance into the larynx, and its branch, the *external laryngeal nerve* (motor), should be traced downward to the crico-thyroid muscle (Fig. 181). The nerve should now be traced backward to its origin from the pneumogastric, the external carotid being elevated to give access to the course of the nerve beneath the artery.

The **lingual artery,** the second branch of the external carotid, passes tortuously upward and inward to disappear under the outer border of the hyoglossus muscle, giving off in its course the small *supra-hyoid artery* which passes just above the great horn of the hyoid bone. The further course of the lingual artery will be seen later. The **facial artery,** the third branch of the external carotid, passes tortuously upward and forward to disappear under the submaxillary gland. Its further course will be traced after the dissection of this gland. The **ascending pharyngeal artery,** the fourth and smallest branch of the external carotid, arises from the deep surface of that vessel, which must therefore be displaced outward and forward in order to expose this branch, and passes vertically upward between the internal carotid and the pharynx, giving off *prevertebral branches* to the prevertebral muscles, *pharyngeal branches* to the pharynx and *meningeal branches* (p. 324). The **occipital artery,** a branch of considerable size, arises from the posterior aspect of the external carotid just at the point where the latter vessel is crossed by the hypoglossal nerve, and passes upward and backward toward the mastoid process, disappearing under the upper outer part of

the posterior belly of the digastric. Its further course at the side of the neck and upon the scalp has been seen (pp. 351 and 317). The **posterior auricular branch** of the external carotid arises from that vessel in the substance of the parotid gland, which may be incised slightly to allow the external carotid to be traced thus far through its substance.

The Internal Carotid Artery.—The **internal carotid artery** should now be followed from its origin at the bifurcation of the common carotid as far as may be possible. It occupies a deeper position than the external carotid and is farther from the mid-line; it is accompanied by the internal jugular vein and the pneumogastric nerve. It gives off no branches in the neck and enters the skull through the carotid canal (Fig. 229). The **relations of the cervical portion of the internal carotid artery** are *in front*, the sterno-mastoid muscle and higher up the parotid gland—separating it from the external carotid—the hypoglossal nerve, the glosso-pharyngeal nerve, the pharyngeal branch of the vagus, the occipital and posterior auricular arteries, and the stylo-glossus and stylo-pharyngeus muscles; *behind*, the sympathetic and superior laryngeal nerves and the rectus capitis anticus major; *externally*, the internal jugular vein and the vagus; *internally*, the pharynx, the ascending pharyngeal artery and the superior laryngeal nerve. The **petrosal portion** of the vessel traverses the carotid canal, giving off the *tympanic* branch (p. 449); the **cavernous portion** has been considered (p. 335) and the **cerebral portion** will be dealt with in the dissection of the brain (p. 496).

The deep situation of the internal carotid artery renders it comparatively immune from injury. From its proximity to the pharynx it may be wounded by a puncture from within the mouth or possibly by operations upon the tonsil; usually, however, it is not vulnerable in the latter case.

The **hypoglossal nerve,** previously mentioned, should be picked up at the point where it crosses the external carotid artery and should be traced backward and upward toward the base of the skull; traced forward transversely across the neck it will be seen to pass under the posterior belly of the digastric and then under the mylo-hyoid muscle, dividing here into numerous *branches* which pass to the extrinsic muscles of the tongue. Its *descending branch* has been dissected (p. 359). Shortly after crossing the external carotid artery, it gives off the *thyro-hyoid branch* to the thyro-hyoid muscle. The **pharyngeal branch of the pneumogastric** may be found by separating the internal and external carotid arteries above the position of the superior laryngeal nerve, and may be traced from its origin from the pneumogastric nerve inward toward the pharynx.

By displacing slightly the nerves and vessels already isolated, parts of the inferior and middle constrictors of the pharynx and of the hyo-glossus and thyro-hyoid muscles will be apparent as forming the floor of this triangle. Beyond recognizing the pharyngeal constrictors

nothing is to be done with them at this time; their fascial covering is to remain intact.

THE SUBMAXILLARY TRIANGLE.—**Boundaries:** above, the lower border of the mandible and a line prolonged to the mastoid process from the angle of the mandible; externally and below, the posterior belly of the digastric; upon the inner side, the anterior belly of the digastric (or the mid-line of the neck) (Fig. 184).

THE MYLO-HYOID MUSCLE.—**Origin,** the mylo-hyoid ridge of the mandible (Fig. 182); **insertion,** the median portion of the body of the hyoid bone and a median raphe extending from the symphysis of the mandible to the hyoid bone; **nerve-supply,** the mylo-hyoid branch of the inferior dental nerve; **action,** to assist in elevating the hyoid bone.

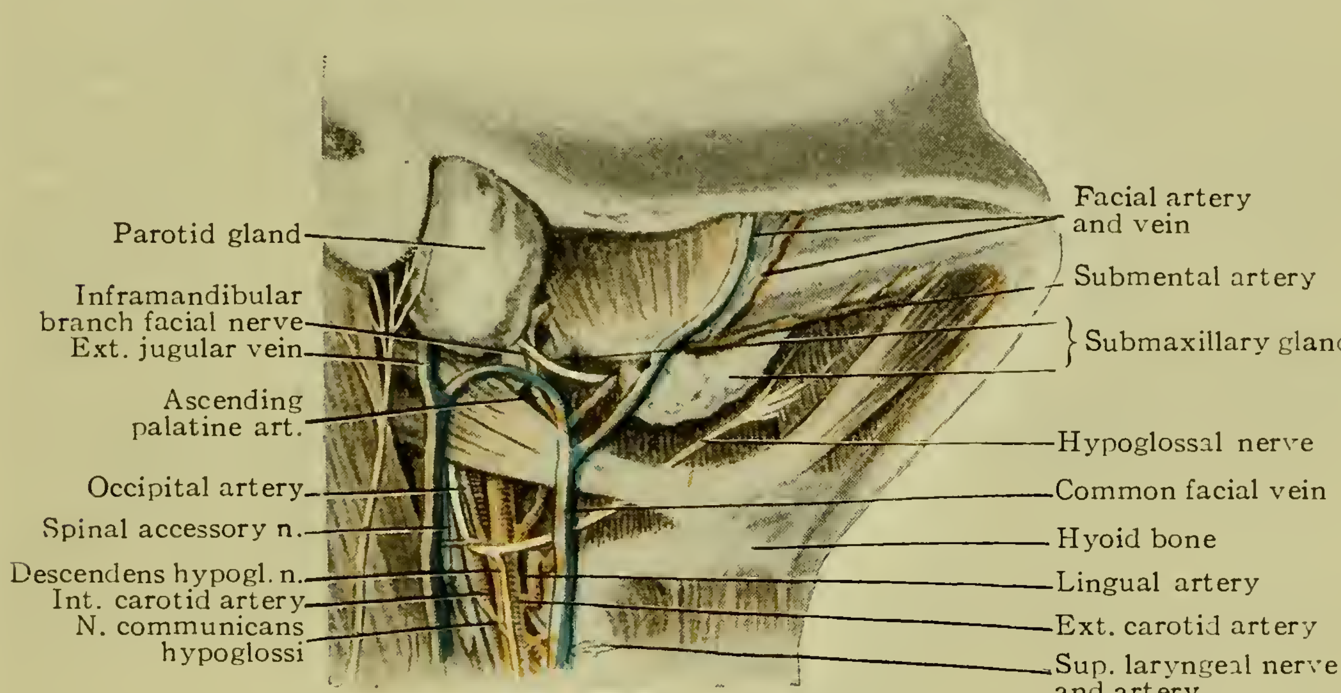

FIG. 184.—Dissection of submaxillary triangle.

To clean the surface of this muscle the anterior belly of the digastric must be elevated and held aside.

The Submaxillary Gland.—This salivary gland lies below and to the mesial side of the body of the mandible in contact with the shallow submaxillary fossa on the mesial surface of that bone (Fig. 184). In the present stage of the dissection it projects as an oblong mass below the level of the bone, appearing to lie within the limits of the submaxillary triangle. The connective tissue should be removed from its surface with as little disturbance of its relations as possible, when the facial vein will be found crossing it superficially downward and outward from the border of the jaw. Lying upon the upper part of this surface under cover of the mandible is the **submaxillary ganglion,** a small mass with nerve-fibres radiating from it in various directions, some of which connect it with the lingual nerve. This lingual branch of the fifth cranial nerve may be found by elevating the chin as far as possible and searching the region

above the submaxillary gland behind the border of the mylo-hyoid muscle. Still farther up and farther back in this same region is the glosso-pharyngeal nerve, arching downward and forward along the outer border of the stylo-pharyngeus muscle (Fig. 186). The **duct** of the gland (Wharton's duct), appearing as a bluish-white, cylindrical structure, should now be sought at its anterior border, and when found, traced forward, with the projecting **deep process** of the gland, under the edge of the mylo-hyoid muscle, which should be displaced forward to a sufficient extent to enable the dissector to follow the duct upward and forward toward the floor of the mouth. The duct, which is about two inches long, passes first beneath the mylo-hyoid muscle and upon the hyo-glossus and genio-hyo-glossus and then between the sublingual gland and the genio-hyo-glossus, the latter being on its mesial side, and opens on a small papilla in the floor of the mouth beneath the tip of the tongue close beside the frænum linguæ (Fig. 217). In tracing the duct, avoid injuring the lingual nerve, which at first lies above the duct—the hypoglossal nerve being below it—and then crosses the course of the duct, usually superficially. The lower, outer border of the gland should now be gently elevated, with due regard for the submental and submaxillary branches of the facial artery (Fig. 184), and a portion of the facial artery will be found in a groove upon its deep surface. This artery should be traced downward to its origin from the external carotid, with care to avoid cutting its branches. Pressure with the tip of the finger immediately behind the gland, toward the inner side of the body of the mandible, will detect a tense band of the cervical fascia, the stylo-mandibular ligament, which separates the submaxillary gland from the parotid gland.

The **blood-supply** of the submaxillary gland is from the facial artery, through its submaxillary and submental branches, and from the lingual. The **nerves** come from the submaxillary ganglion, which contributes fibres derived from the lingual branch of the fifth—some of these being facial fibres acquired through the chorda tympani—and also sympathetic fibres from the plexus of the facial artery. The **lymphatics** pass to the submaxillary lymph-nodes.

The **sublingual gland** (p. 465) may be detected by burrowing beneath the mylo-hyoid muscle—the head being over-extended—or by removing the muscle, which, however, should not be done now, though it may be cut transversely, to be afterward sutured.

The **facial artery** (a. maxillaris externa), arising from the external carotid just above the origin of the lingual (Fig. 185), should now be followed in its course in the neck—its **cervical portion**—as it passes tortuously upward beneath the submaxillary gland in a groove in its deep surface to reach the lower border of the mandible at the anterior border of the masseter (Fig. 184). The **branches** of the cervical portion of the

facial artery are the *ascending palatine* (Fig. 185), a small vessel, which passes upward between the stylo-pharyngeus and the stylo-glossus muscles across the outer surface of the superior constrictor to terminate in branches to the soft palate, the tonsil and the Eustachian tube; the *tonsillar* (Fig. 185), the origin and course of which are close to the inner

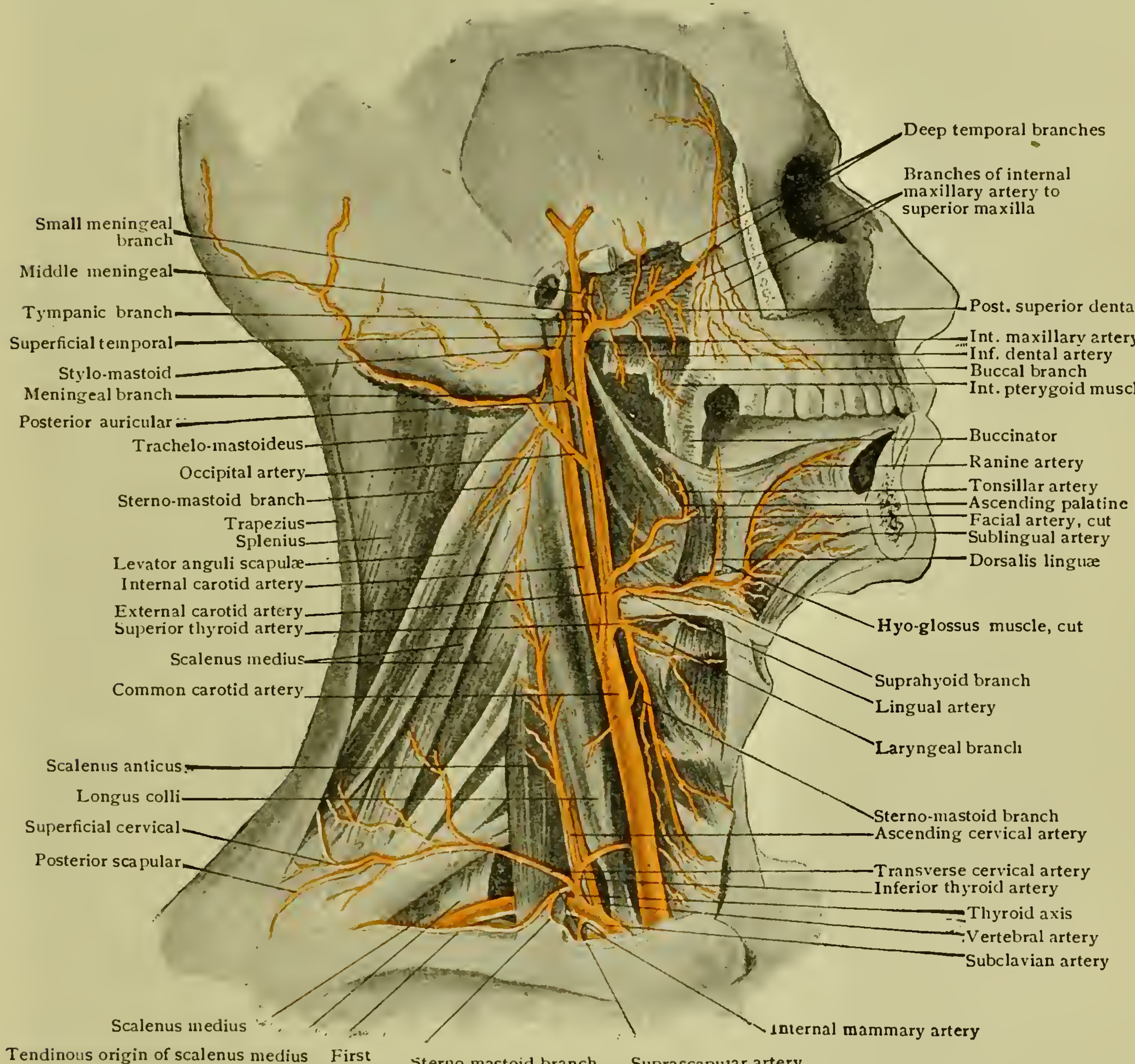

FIG. 185.—Deeper dissection, showing carotid and subclavian arteries.

side of the latter vessel; the *glandular* or *submaxillary* (Fig. 182), to the submaxillary gland; the *submental* (Fig. 178), a rather large branch, which passes forward below the mandible to ascend upon the face near the chin. The **facial portion** of the artery will be seen in the dissection of the face (p. 398).

The Triangle of Lesser.—Replacing the submaxillary gland as nearly as possible in its normal position, note that the submaxillary triangle is

subdivided by a white band which passes across the lower part of the triangle from the posterior belly of the digastric muscle to the border of the mylo-hyoid; this is the **hypoglossal nerve,** this portion of which should now be cleaned, and which forms the *base* of the triangle of Lesser, while the posterior belly of the digastric and the free border of the mylo-hyoid form its *sides* (Fig. 184). The *floor* of this triangle is the hyo-glossus muscle, which should now be denuded, it being necessary for this purpose to displace the mylo-hyoid muscle forward and the submaxillary gland upward over the jaw, where it may be held by a hook.

The significance of the triangle of Lesser is that it is the most favorable situation for tying the lingual artery, which passes inward and slightly upward beneath its floor, *i.e.*, the hyo-glossus muscle, the boundaries of the triangle serving as guides to the position of the vessel.

The Hyo-Glossus Muscle (Fig. 185).—**Origin,** the greater and lesser horns and body of the hyoid bone; **insertion,** the muscular substance of the tongue; **nerve-supply,** the twelfth cranial or hypoglossal nerve; **action,** to depress the side of and to retract the protruded tongue. The forepart of this muscle being overlapped by the mylo-hyoid muscle, forward displacement of the latter is necessary in order to expose the hyo-glossus. The fibres arising from the body of the hyoid bone are sometimes described as the **chondro-glossus.**

The Lingual Artery.—The lingual artery may be easily recognized at the outer or posterior border of the hyo-glossus muscle and should be cleaned and followed downward to its **source** in the external carotid, care being exercised to avoid cutting its branches. This *first* or *oblique portion* of the lingual, *i.e.*, from its origin to the outer border of the hyo-glossus, is relatively superficial and lies upon the middle pharyngeal constrictor; it gives rise to the first **branch,** the *small supra-hyoid branch,* which passes inward just above the great horn of the hyoid bone. The **second part** of the artery, which lies also upon the middle constrictor, but under the hyo-glossus muscle and therefore beneath the floor of the triangle of Lesser, should now be exposed by incising the hyo-glossus; this will expose also the origin of its *dorsalis linguæ branch* which passes upward beneath the hyo-glossus to reach the dorsum of the tongue; giving branches to the soft palate and tonsil (Fig. 185). Beyond or at the inner border of the hyo-glossus the lingual gives off the *sublingual artery* which passes to the sublingual gland and adjacent parts, the trunk of the lingual continuing as the *ranine* or *deep lingual artery* to the tip of the tongue. On the under surface of the free portion of the tongue the ranine artery is close to the median plane, on the outer surface of the genio-hyo-glossus and covered by the mucous membrane, accompanied by the terminal branches of the lingual nerve.

The lingual artery may be implicated in *cut throat,* for which *ligation* may be necessary. It may be tied also as a preliminary to the operation for *extirpation of*

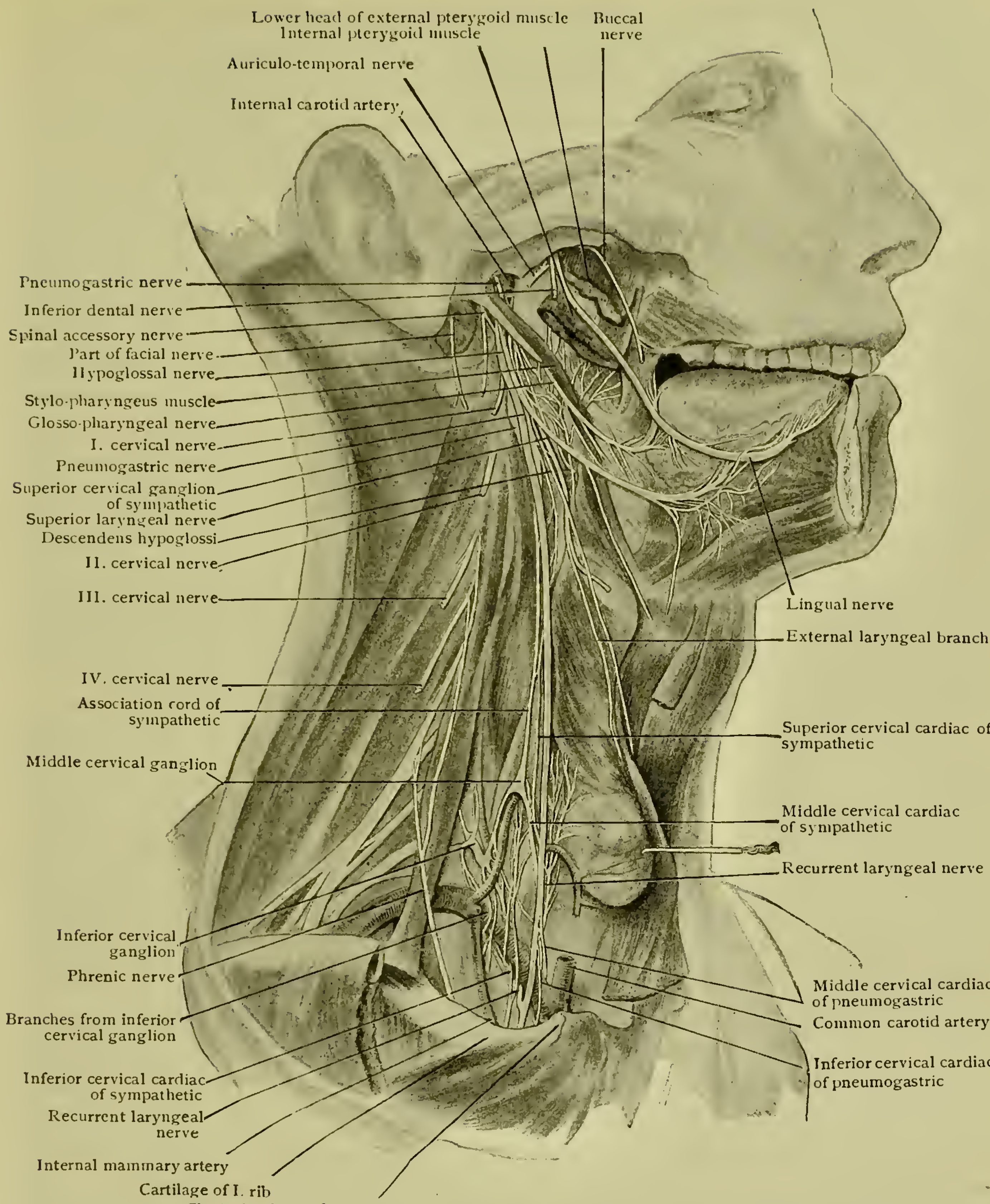

FIG. 186.—Deep dissection of right side of head and neck, showing lingual, glosso-pharyngeal, pneumogastric, hypoglossal and sympathetic nerves.

the tongue as a means of diminishing the loss of blood during that operation; or to retard the progress of *cancer of the tongue* by lessening the blood-supply of that organ. As mentioned above, the second portion of the lingual or that part contained within the triangle of Lesser, is the point of election for ligation.

The **occipital artery** should now be traced from its **origin** on the posterior aspect of the external carotid, where it is crossed by the hypoglos-

sal nerve (Fig. 185), in its course upward and outward beneath the stylo-hyoid and the posterior belly of the digastric and the lower part of the parotid gland to the groove on the inner surface of the mastoid process and then under the sterno-mastoid and the splenius. The latter muscles are to be incised to the extent necessary to expose the vessel (Fig. 163). The further course of the artery has been seen (pp. 340 and 351).

The **branches** of the occipital artery are the *muscular*, given off along its course; the *superior sterno-mastoid*, passing downward to the deep surface of the sterno-mastoid muscle; the *posterior meningeal*, which reach the dura mater of the posterior cranial fossa through the jugular foramen; the *auricular*, passing over the mastoid process to reach the pinna; the *mastoid*, which traverses the mastoid foramen to supply the mastoid cells, the diploë and the dura mater; and the *arteria princeps cervicis* (p. 341), the anastomosis of the deep branch of which with the profunda cervicis will be dissected in connection with that vessel (p. 385). The *occipital* branches to the scalp have been dissected (p. 317).

The anastomoses of the occipital artery that are important in connection with the establishment of the collateral circulation after ligation of the common carotid or of the proximal part of the external carotid are, upon the scalp, with the occipital artery of the opposite side and in the neck, through its princeps cervicis branch, with the profunda cervicis and the superficial cervical of the subclavian.

The **posterior auricular artery,** the last branch of the external carotid in the neck, arises under the lower part of the parotid gland just above the posterior belly of the digastric, from which point it should be traced upward and backward as it passes beneath the gland and in front of the styloid process, across the spinal accessory nerve and under the facial nerve to the sulcus between the cartilage of the ear and the mastoid process, above which it **divides** into the *auricular branch* (p. 317) for both surfaces of the auricle and the *mastoid* for the mastoid region of the scalp. In addition to the terminal branches, *glandular branches* pass to the parotid, *muscular branches* to related muscles and the *stylo-mastoid branch*, which occasionally arises from the occipital, enters the facial canal of the temporal bone at its external orifice, the stylo-mastoid foramen. It will be further considered in connection with the middle ear (p. 449).

The Hypoglossal or Twelfth Cranial Nerve.—This nerve has been dissected for the most part (p. 372); it should now be followed in the deeper part of its course as well as at its termination. Catching it up at the point where it crosses the external carotid artery, it may be followed almost to the base of the skull if the chin is pulled well upward. Tracing its course from above—after emerging through the anterior condyloid foramen, it passes beneath the internal carotid artery and the internal jugular vein, communicating here with the vagus, then forward between the artery and vein to curve forward and downward across first

the internal carotid and then the external carotid and the origin of the occipital artery to reach finally the lower angle of the submaxillary triangle, where it terminates in *muscular branches* for the hyo-glossus, stylo-glossus, genio-hyo-glossus and genio-hyoid muscles and *lingual branches* for the intrinsic muscles of the tongue. The descending branch (descendens hypoglossi) (p. 359) and the muscular branches for the hyoid depressors (p. 360) have been dealt with. The terminal branches should now be traced.

The hypoglossal is thus seen to be the nerve-supply, through its spinal branches, acquired through communicating rami that come to it from the first and second cervical nerves, of the hyoid depressors, and also of the *extrinsic muscles of the tongue*, aiding also in the supply of the *intrinsic muscle*, the *lingualis*. Hence injury of this nerve may result in motor paralysis of the corresponding half of the tongue.

THE STYLO-PHARYNGEUS.—**Origin,** the styloid process of the temporal bone near its base; **insertion,** the side of the pharynx, blending with the constrictors, and the posterior border of the thyroid cartilage; **nerve-supply,** the glosso-pharyngeal nerve; **action,** to aid in elevating and widening the pharynx and in elevating the larynx (Fig. 186).

This small muscle passes downward and inward between the superior and inferior constrictors. To reach it the head must be over-extended and the face turned toward the opposite side.

The Glosso-Pharyngeal Nerve.—The glosso-pharyngeal nerve will be found passing along the outer border of the stylo-pharyngeus muscle, arching inward across the muscle at its lower end to pass beneath the hyo-glossus muscle. To find the nerve, it is necessary to raise the border of the jaw as above and to work inward above the position of the submaxillary gland, the stylo-pharyngeus muscle serving as a guide to the nerve. It is usually considerably smaller than the lingual nerve. Traced upward and outward it will be found to have emerged from the skull through the middle compartment of the jugular foramen in front of the vagus and spinal accessory nerves and to pass down the neck and forward between the internal jugular vein and the internal carotid artery, then to cross in front of the artery to the stylo-pharyngeus muscle. It gives off one *muscular branch*, as noted above, to the stylo-pharyngeus muscle, and prior to this gives *carotid branches* to the internal carotid artery and small *pharyngeal branches* which join the pharyngeal branches of the vagus and sympathetic to form the **pharyngeal plexus** found on the outer surface of the middle pharyngeal constrictor (p. 383). Near its termination, *tonsillar branches* arise for the tonsils and adjacent parts, after which the nerve divides into *two lingual branches* for the supply of the circumvallate papillæ of the tongue and the mucous membrane on the posterior third of its dorsal surface. The tympanic branch of the glosso-pharyngeal is noted in connection with the middle ear (p. 449).

The glosso-pharyngeal is the nerve of taste (p. 467). It forms some *communications* with the facial, the pneumogastric and the sympathetic. Its distribution to the tongue will be further considered in connection with that organ (p. 467).

The Pneumogastric or Vagus or Tenth Cranial Nerve.—The vagus has been followed throughout its course in the neck and has been seen to occupy a position within the sheath of the carotid vessels, which it enters upon leaving the skull through the middle division of the jugular foramen, being at first between and behind the internal carotid artery and the internal jugular vein and later sustaining the same relation to the common carotid artery and the internal jugular. Traced to the root of the neck, the right nerve crosses the subclavian artery behind the right innominate vein (Fig. 186), while the left one passes into the thorax between the left carotid and left subclavian arteries behind the left innominate vein. Its further course will be seen in the dissection of the thorax (p. 744).

In the jugular foramen the vagus presents a small ganglion, the **superior** or **jugular ganglion,** and below the foramen the larger **inferior ganglion.** Immediately below this, it receives the accessory fibres of the spinal accessory nerve which have passed through the inferior ganglion.

The **branches** of the vagus **in the neck**—the **branches** in the **jugular fossa** are the *meningeal* and the *auricular* (p. 438)—are the *pharyngeal* (p. 372), the chief motor nerve of the pharynx, which passes inward across the internal carotid artery to join the pharyngeal plexus (p. 383); the *superior laryngeal* (p. 371), the chief sensory nerve of the larynx through its *internal laryngeal branch* (Fig. 182), while its *external laryngeal branch* supplies the crico-thyroid muscle (Fig. 181); the *cervical cardiac branches*, the *superior* arising in the upper part of the neck and passing down either within the carotid sheath or behind it and communicating with the sympathetic cardiac branches, the *inferior* arising at the root of the neck and passing over or beneath the subclavian artery (Fig. 186); and the *right inferior* or *recurrent laryngeal* (the *left nerve* arising in the thorax and winding around the arch of the aorta). These branches have been encountered and dissected. The cardiac branches are variable in number; sometimes there are two and sometimes three. They all go to join the deep cardiac plexus (Fig. 357) save the left inferior cardiac, which joins the superficial plexus.

The *asymmetry* of the recurrent laryngeal nerves of the two sides is due to the asymmetrical disposition of the arterial trunks with which they are related. At the stage of the symmetrically arranged visceral-arch vessels each recurrent laryngeal nerve winds around the fourth visceral-arch vessel of its own side. When the right fourth vessel becomes the right subclavian artery and the left becomes the arch of the aorta, the left nerve follows the latter vessel in its change of position.

The **superior cervical ganglion of the sympathetic** should be looked for in front of the transverse processes of the second and third cervical vertebræ upon the rectus capitis anticus major (Fig. 186), it being necessary to displace the sterno-mastoid backward and the internal jugular vein and internal carotid artery inward to disclose this ganglion, which appears as a rounded mass about an inch in length and one eighth of an inch or more in width. Regard should be had in isolating it for its numerous **branches of communication** (somatic branches), these being the *rami communicantes*, which connect it with the first four cervical nerves —the superior ganglion representing four coalesced ganglia—and the branches going to the petrous ganglion of the glosso-pharyngeal, to the hypoglossal and to the two ganglia of the pneumogastric.

Its **branches of distribution** (visceral branches) are the *pharyngeal*, which passes behind the carotid sheath to join the pharyngeal plexus (p. 383); the *superior cervical cardiac*, the *vascular* and the *vertebral*, the last named being small branches which go to the bones, ligaments and anterior muscles of the adjacent portion of the spine.

The **cardiac branch** (p. 369) passes down the neck within the carotid sheath or behind it, being often joined by the middle or the inferior cardiac branch, or by both. All the cervical cardiac branches of the sympathetic join the deep cardiac plexus except the left superior branch, which joins the superficial plexus (compare p. 380).

The **vascular branches** include those which supply sympathetic fibres to the *external carotid artery* and its branches (e.g., the plexuses of the facial and the middle meningeal arteries) and the *ascending* or *internal carotid branch* (Fig. 219). The latter accompanies the internal carotid artery into the carotid canal and divides into two branches which respectively form the carotid and cavernous plexuses (Fig. 219). The ascending branch can be followed but a very short distance at this stage of the work (vide p. 336). The *association cord* may be traced from the lower end of the ganglion to the middle or thyroid ganglion.

The Cervical Plexus.—The cervical plexus (Fig. 187) is constituted by the ventral divisions of the first four cervical nerves which intercommunicate upon their exit from the intervertebral foramina, the fourth nerve being also connected with the fifth.

The plexus lies upon the levator anguli scapulæ and scalenus medius and is covered by the sterno-mastoid. The **superficial branches** have been encountered (pp. 350 and 351).

The **deep branches** comprise the *muscular* and the *communicating branches*. The **muscular branches** are those to the *recti capitis lateralis* and *antici major* and *minor* from the first nerve or the loop between the first and second; to the *sterno-mastoid* from the second (p. 352); to the *trapezius* and *levator anguli scapulæ* from the third and fourth (p. 353); to the *scalenus medius* from the third or fourth or from both (p. 353); to

the *diaphragm* (the phrenic nerve) from the fourth chiefly, but also from the third and fifth (p. 357). The **communicating branches** include filaments from the loop between the first and second to the *vagus*, *hypoglossal*, and *sympathetic;* the *rami communicantes* to the superior cervical ganglion (p. 381); branches from the second nerve to the *spinal accessory* (p. 354); and *communicantes hypoglossi* from the first and second nerves to form, with the descending branch of the hypoglossal nerve, the ansa hypoglossi (p. 359).

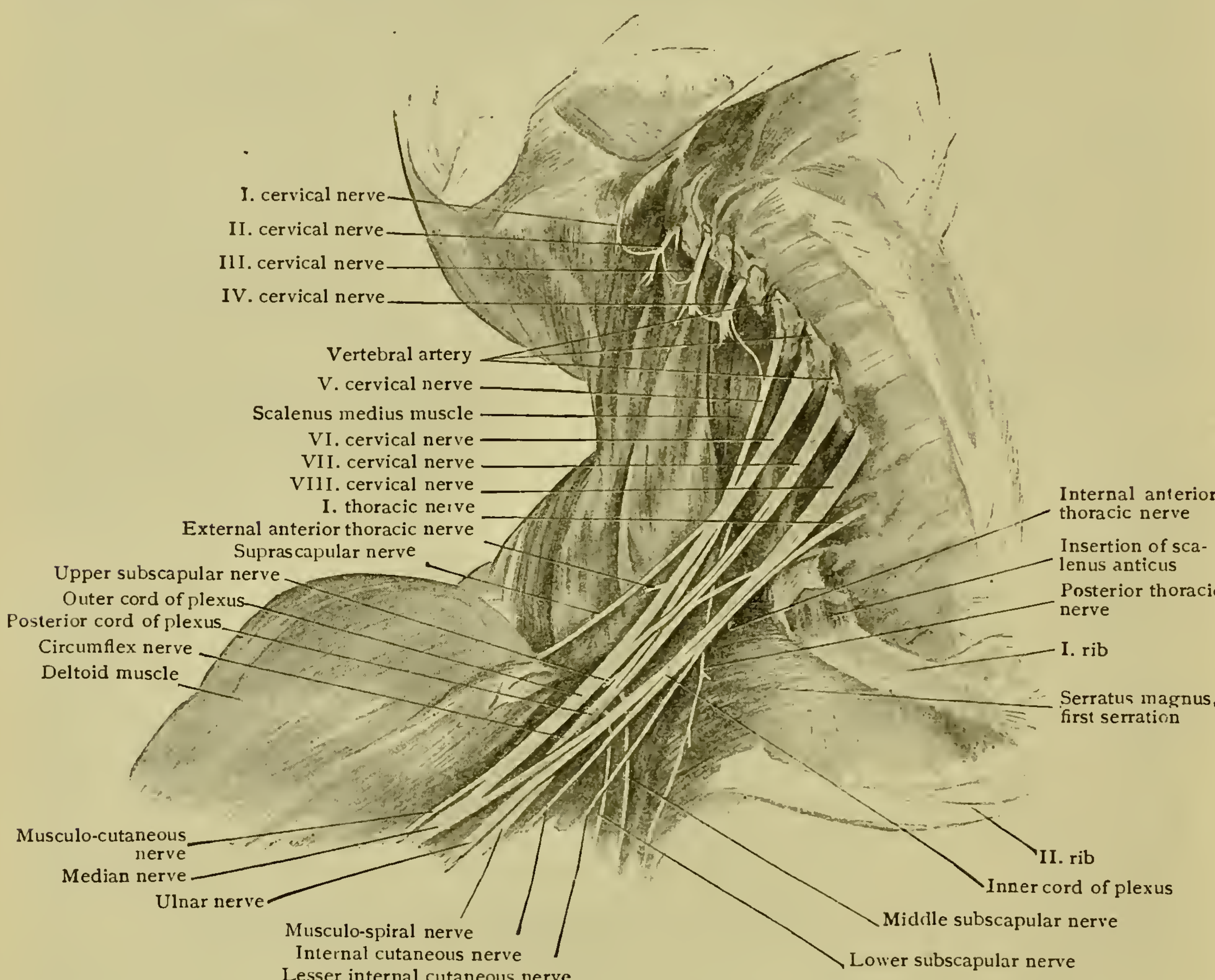

FIG. 187.—Deep dissection of neck, showing constitution of right brachial plexus.

Practically all these branches save those to the lateral and anterior straight muscles of the head and a few of the smaller communicating branches have been dissected as noted above. The ventral divisions of the cervical nerves themselves should now be identified, as should also as many of the branches named as possible.

The **phrenic nerve** or **internal respiratory nerve of Bell** has been followed to its point of entrance into the thorax (p. 357); its course through the thorax and distribution to the diaphragm of course pertain to the dissection of the thorax and abdomen. As the phrenic nerve passes downward upon the anterior scalene muscle, and as the posterior border of this muscle is just beneath the posterior border of the

sterno-mastoid, at and a little way above the clavicle, the position of the nerve is easily marked out upon the surface. *Irritation of the phrenic*, as by the pressure of an aneurism (p. 370), causes hiccough and cough. The chief origin of the phrenic from the third cervical nerve makes it liable to injury in fracture-luxation of the third cervical vertebra and explains the fatality of this accident, since from paralysis of both phrenics the function of the diaphragm is lost.

The **ascending cervical branch** of the inferior thyroid artery should be sought in front of the transverse processes of the vertebræ, displacing the structures previously dissected to the extent necessary for the purpose. It *anastomoses* with branches of the vertebral, occipital and ascending pharyngeal, sending some branches into the spinal canal.

The **pharyngeal plexus** should be sought on the outer surface of the middle constrictor of the pharynx. Being constituted by the *pharyngeal branch of the pneumogastric*, and the *pharyngeal branches of the glosso-pharyngeal* and of the *superior cervical ganglion* of the sympathetic, any one of these nerves may be utilized as a guide to the plexus. Its **branches** perforate the wall of the pharynx to supply the muscles and the mucous membrane of the latter.

The general form of the pharynx and its relation to the vertebræ and the structures of the neck may be appreciated by displacing it somewhat to one or other side and pulling it forward from the spinal column; it will be more fully studied at a later stage of the work (p. 456).

The dissector of the upper limb having effected the disarticulation of the clavicle from the sternum, the dissection of the more deeply placed structures at the root of the neck should be completed.

The Subclavian Artery.—The *right* subclavian artery **arises** at the bifurcation of the innominate behind the sterno-clavicular articulation; the *left*, from the arch of the aorta. The **termination** in each case is at the outer border of the first rib, where it becomes the axillary artery, the vessel describing a curve in the neck with the convexity upward, the summit of which is a variable distance, usually about a half-inch, above the clavicle. Its **surface line,** therefore, is a curved line drawn from the sterno-clavicular joint to the lower border of the middle of the clavicle, the summit of the convexity of the curve being placed at a point a half-inch above the clavicle a little to the inner side of the posterior border of the sterno-mastoid muscle. As noted above, the scalenus anticus, passing across the artery superficially, between it and the subclavian vein, divides it into *three parts* (Fig. 181).

The First Portion of the Subclavian Artery.—This includes that part of the vessel between its origin and the inner border of the scalenus anticus. In cleaning the artery of the right side one finds crossing it superficially the internal jugular and vertebral veins—the anterior jugular vein will have been removed with the sterno-hyoid muscles—the vagus, the phrenic nerve, usually one or more cervical cardiac branches of the vagus and one or more cervical cardiac branches of the sympathetic.

On the left side of the body the nerves mentioned are in front of but parallel with the artery, and the left common carotid and the beginning of the left innominate vein are also found in front in addition to the internal jugular and vertebral veins and the terminal portion of the thoracic duct. In dissecting the right vagus, the recurrent laryngeal nerve (p. 380) will be found encircling the vessel or arising a little below it and passing up behind it. The **right lymphatic duct,** when present, is found here also, as a small vessel a half-inch in length (Fig. 366), opening into the junction of the subclavian and internal jugular veins. It may be represented, however, by several lymphatic trunks, the jugular, subclavian and broncho-mediastinal ducts, which may be quite difficult to find. The internal jugular and vertebral veins should be cut near their terminations, two ligatures being first applied to each.

The inferior aspect of the vessel should be separated with the handle of the scalpel from the subclavian vein, which lies below and on a plane anterior to the artery.

The **branches** of the first part of the *right* subclavian are the *vertebral*, the *thyroid axis* and the *internal mammary;* of the *left*, the same vessels and in addition the *superior intercostal.* The **vertebral artery,** usually the first and largest branch, must be sought at the beginning of the subclavian, in the case of the right vessel, on its upper and posterior aspect (pp. 366 and 487) (Fig. 181).

The **thyroid axis** (truncus thyreocervicalis), arising from the front surface of the subclavian (Fig. 185), should be cleaned and its three **terminal branches,** the *inferior thyroid*, the *transverse cervical* and the *suprascapular*, noted. The **inferior thyroid** and its branches have been dissected (pp. 366 and 383).

The **transverse cervical** (a. transversa colli) has also been dissected for the most part (pp. 355 and 356). Having traced it outward across the phrenic nerve and anterior scalene muscle and over or between the trunks of the brachial plexus to its division beneath the trapezius into its two **terminal branches** (p. 20), the *superficial cervical* (ramus ascendens) and the *posterior scapular* (ramus descendens), the former should be followed upward to its anastomosis with the superficial branch of the princeps cervicis of the occipital.

The **suprascapular artery** (a. transversa scapulæ) should be noted as passing outward over the phrenic nerve and anterior scalene muscle below the transverse cervical. Its course and branches are given on page 24.

The **internal mammary artery** arises from the inferior surface of the subclavian opposite the origin of the thyroid axis and behind the junction of the internal jugular and subclavian veins. It is crossed by the phrenic nerve. Its further course is to be followed in the dissection of the thorax.

The deep relations of the first part of the subclavian artery will be best studied after exposing the second part of the vessel.

The Second Portion of the Subclavian Artery.—This part of the vessel is that embraced within the limits of the anterior scalene muscle, which, lying in front of it, separates it from the subclavian vein. The phrenic nerve, instead of crossing the first part of the artery as noted above, may, on the right side, maintain its relation with the muscle and be separated by it from the second part of the vessel. The scalenus anticus should now be detached from the first rib and reflected upward. The only **branch** of the second portion is the *superior intercostal;* on the left side this vessel arises from the first portion of the artery.

The superior intercostal artery (truncus costocervicalis) should be followed from its origin from the upper and posterior aspect of the subclavian backward and then downward behind the pleura in front of the necks of the first and second ribs to the first intercostal space (p. 745). On its outer side it is related with the first thoracic nerve and on its inner side with the inferior cervical and first thoracic sympathetic ganglia. Before turning downward it gives off its only named **branch,** the *profunda cervicis* (a. cervicalis profunda), which should now be followed backward between the seventh cervical transverse process and the first rib—where it gives off a branch which enters the spinal canal—and then up the back part of the neck, beneath the complexus and upon the semispinalis colli (p. 341) to anastomose with the princeps cervicis of the occipital. This last stage of the dissection can be done to better advantage after the detachment of the head and neck from the trunk. The importance of this anastomosis has been noted (p. 378).

The subclavian artery should now be cautiously separated from the structures beneath and behind it by blunt dissection and elevated. The structures thus exposed are, from within outward, the association cord of the sympathetic, the dome of the pleura and apex of the lung, the scalenus medius and the first rib. As the vessel is displaced the recurrent laryngeal nerve, which winds around the first part of the right subclavian, is carried with it. Each one of the structures named should be cleaned up and examined and the vessel should then be replaced and its relations studied.

The Relations of the First Part of the Subclavian Artery.—*In front,* the clavicular origin of the sterno-mastoid, the anterior jugular vein, the sterno-hyoid and sterno-thyroid muscles, the internal jugular and vertebral veins, the vagus and frequently the phrenic nerve and in many cases one or more cervical cardiac nerves, in the case of the *right subclavian;* the anterior relations of the *left subclavian* differ in that the nerves mentioned pass parallel with the vessel instead of crossing it, since the left artery ascends into the neck from the thorax (p. 383)

and the terminal part of the thoracic duct and the beginning of the left innominate vein are also found in front of it.

Behind, the recurrent laryngeal nerve, the sympathetic association cord and the pleura and apex of the lung.

Below, the recurrent laryngeal nerve, the pleura, the subclavian vein.

The Relations of the Second Part of the Subclavian Artery.—*In front,* the sterno-mastoid and scalenus anticus, the phrenic nerve, the external jugular vein and the subclavian vein in part; *behind,* the scalenus medius and the pleura; *above,* the brachial plexus; *below,* the pleura.

The **relations of the third part** of the vessel have been studied (p. 358).

The dissector may find **variations in the origin**—and consequently in the **course**—of the subclavian arteries, these variations being usually referable to abnormalities of development, i.e., the suppression of the vessel wholly or in part and the persistence of certain arterial trunks that normally disappear. Thus the right artery may arise at a somewhat *higher* or *lower* point than usual; or as a *separate trunk* from the beginning of the aortic arch, holding then its usual course; or from a point farther along the aortic arch as the *second* or *third branch* of the latter, passing then behind the right carotid; or from the *left extremity* of the arch as its last branch, in which case it passes upward and to the right behind the trachea—sometimes also behind the œsophagus—and behind the right carotid to attain its usual relation to the first rib; or it may arise from the thoracic aorta, probably this and the last named condition being instances of the persistence of the distal part or dorsal stem of the right fourth visceral-arch vessel, which normally becomes obliterated, and the disappearance of its proximal part or ventral stem, which normally becomes the right subclavian artery. **Variations in the course without variation in the origin** are exemplified by those cases in which the artery passes over or through the anterior scalene muscle.

The deep situation and complicated relations of the first and second parts of the vessel are unfavorable to its ligation in these portions (vide p. 358), although it has been done successfully. Its liability to injury in fractures of the clavicle has been noted (p. 69).

The Subclavian Vein.—This venous trunk **originates** as the continuation of the axillary vein at the outer border of the first rib and **terminates** by uniting with the internal jugular to form the innominate vein. It should be cleaned and its **relations** noted; these are, *in front,* the clavicle and subclavius muscle; *behind* and *above,* the subclavian artery, the scalenus anticus and the phrenic nerve; *below,* the anterior groove on the first rib, after leaving which it is in contact with the pleura. Note the **tributaries** as being the *external jugular vein,* which opens into the subclavian upon the outer side of the anterior scalene or in front of that muscle (Fig. 183), and the *anterior jugular* when that vessel does not terminate in the external jugular. Its only **valves** are placed distal to the orifice of the external jugular. The right vein also receives the right lymphatic duct, and the left the thoracic duct.

The further dissection of the neck must be deferred until later stages of the work (pp. 456 and 486).

THE FACE.

The dissector should examine the **bones of the face** (Fig. 160) as a preparation for the work of dissection, noting the various cavities it presents, as the **orbits,** the **nasal cavities** and the **oral cavity,** the *situation*, *relations* and *articulations* of the individual bones, the *foramina*, and the chief *areas of muscular attachment*. Let him examine particularly the **zygomatic fossa** and its *communications* with the orbital cavity through the spheno-maxillary fissure and with the spheno-maxillary fossa through the pterygo-maxillary fissure, noting also the *communication* of the spheno-maxillary fossa with the cavity of the cranium through the foramen rotundum and with the orbit through the spheno-maxillary fissure. The articulation of *the condyle* of the **mandible** with the *glenoid cavity of the temporal bone*, the relation of its *coronoid process* to the *zygomatic arch* and the *inferior dental canal* of the same bone should receive like attention.

THE SURFACE ANATOMY.

The **frontal eminences** at the upper limit of the face, forming the prominence of the forehead; the **glabella,** the prominence just above the root of the nose; the **superciliary ridges,** extending outward from the glabella and the **supraorbital** arches, corresponding to the position of the frontal sinuses, have been mentioned in connection with the dissection of the scalp.

The **region of the orbit** presents conspicuously the margins of the orbital cavity. The **supraorbital** arch, the upper margin of the orbit, is easily palpated; following it to its inner extremity the finger detects the internal **angular process of the frontal bone,** while at its outer extremity is the **external angular process**, a more easily palpable landmark.

The **supraorbital foramen** or notch is situated at the junction of the inner and middle thirds of the supraorbital ridge and the **supra-orbital artery** and **nerve** which traverse this foramen are thus easily located. The **external margin** of **the orbit** is easily followed, as is likewise the **inferior margin.**

The **infraorbital foramen** may be recognized by noting the slight depression just below the lower margin of the orbit in line with the supra-orbital foramen, where a slight degree of pressure by the finger will elicit in the living subject the discomfort or pain due to pressure upon the **infraorbital nerve** which makes its exit in company with the **infra-orbital artery** through this foramen.

The **palpebral fissure** should be noted as the interval between the free borders of the upper and lower eyelids, its inner angle or **inner canthus** being more obtuse than the outer (Fig. 188).

The **puncta lachrymalia** are minute apertures found one on the edge of each eyelid about one quarter of an inch from its inner extremity. With a very fine probe or bristle these apertures may be penetrated and the probe will pass inward through a small canal in each case, the **canaliculus,** of which the punctum above referred to is the external orifice. The two canaliculi converge at the inner canthus and open into the **lachrymal sac** or **tear sac,** from which the **nasal duct** conveys the tears into the inferior meatus of the nose.

The **conjunctiva** is the mucous membrane which lines the inner surfaces of the eyelids (*palpebral conjunctiva*) and covers the anterior third of the eyeball (*ocular conjunctiva*); the line of continuity between the ocular and the palpebral conjunctiva, or the line of reflection of the conjunctiva from the eyelid to the globe of the eye, forms the *fornix conjunctivæ*.

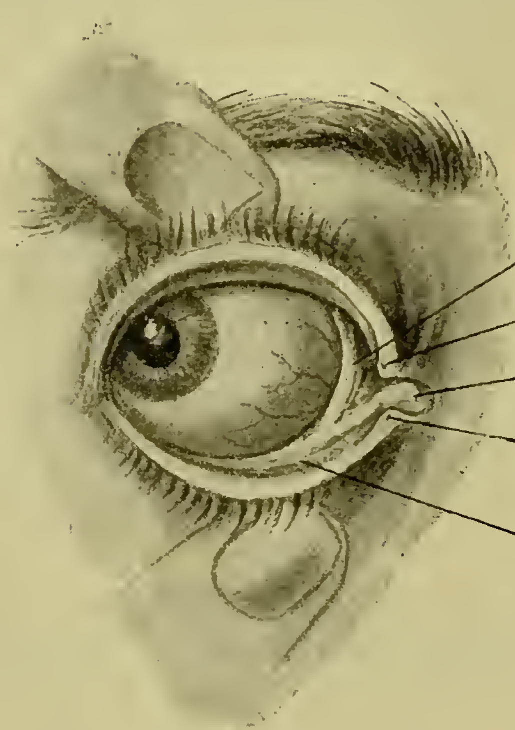

Fig. 188.—View of living eye, showing relation of eyeball to palpebral fissure and details of inner canthus.

Palpebral and ocular conjunctiva together, therefore, would enclose a space the only opening of which is the *palpebral fissure* or the space between the edges of the lids. The upper and lower parts of this space are designated respectively the upper and lower conjunctival culs-de-sac. The conjunctiva may be inspected by everting the eyelids and noting the lines of reflection of the membrane from the eyelids to the eyeball.

Examine the inner canthus (Fig. 188) and note the small pink elevation, the **caruncula lachrymalis**, an isolated patch of modified skin, and the **plica semilunaris** as a crescentic band or fold external to it. The **membrana nictitans,** the third or lateral eyelid of birds and some other animals of which the plica is the rudimentary representative in man, may be easily demonstrated in the cat by reflecting a strong light into the animal's eye, when the membrane will be projected outward from the inner canthus.

The student will do well to study the conjunctiva in the living subject. The palpebral conjunctiva will be seen to be movable upon the underlying tissues, while the ocular conjunctiva is not, the latter being more adherent, especially over the cornea. A clinical illustration of this relation is seen in *chemosis*, in which there is edema or dropsy of that part of the ocular conjunctiva which surrounds the margin of the cornea, causing this part to swell, while the part of the conjunctiva which covers the cornea does not participate in the swelling and, therefore, is relatively depressed.

The **Meibomian glands,** sebaceous glands situated between the tarsal plate and the conjunctiva near the free border of the eyelid, appear through the conjunction as yellowish beaded lines running back from the edge of the lid. They are readily seen in the living subject upon eversion of either lid.

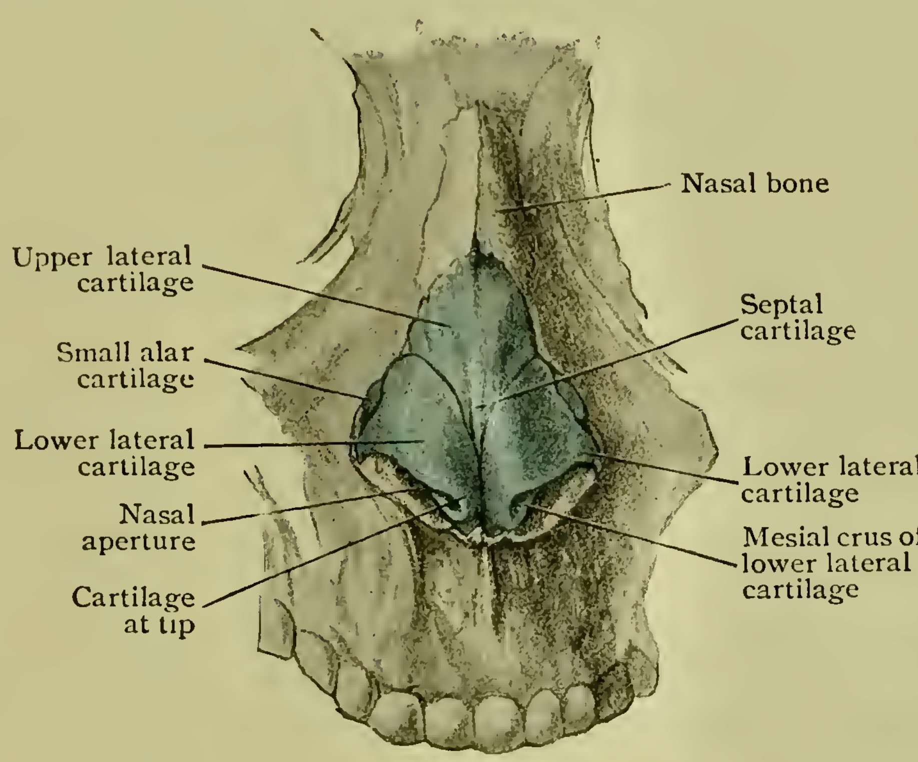

Fig. 189.—Bony and cartilaginous framework of nose, front aspect.

Inflammation of these glands resulting in the occlusion of their ducts and the consequent accumulation of their secretion constitutes the condition known as *chalazion.*

The eyeball should now be injected with fifteen per cent. formalin solution, the needle puncture being made through the sclera about one third of an inch behind the margin of the cornea. The edges of the eyelids should then be stitched together.

The **nose,** one of the most conspicuous features of the face, is composed partly of bone and partly of cartilage (Fig. 189). The tip of the finger may detect in the mid-line of the nose a slight groove which indicates the line of union between the two nasal bones, while about midway between the bridge and the tip of the nose the lower margin of the bony part of the structure may be recognized, this margin being formed by the nasal bones and the nasal processes of the superior maxillæ.

Through the notch on the margin of the nasal bone the **external branch of the nasal nerve** (Fig. 163) escapes from the nasal cavity to reach the integument upon the side of the nose.

Fractures of the nasal bones by direct violence are not uncommon, owing to their superficial situation, and are apt to be attended with considerable swelling and discoloration of the soft parts. If there is no displacement of the bone, fractures may be difficult to recognize; if there is displacement, the nasal mucous membrane may be lacerated, producing nasal hemorrhage and *subcutaneous emphysema* of the soft parts about the nose, that is, an infiltration of the tissues with air, giving them a crackly "feel," due to the air having been forced into the tissues through the laceration in the mucous membrane in the act of blowing the nose.

The **upper lip** presents in the mid-line a groove, the **philtrum,** running vertically downward from the nasal septum and terminating at the edge of the lip in a small **labial tubercle.** On either side of the philtrum is the **naso-labial ridge,** due to the presence of vertically directed bundles of muscular tissue, the naso-labialis, belonging to the orbicularis oris.

The **mental foramen** (*mentum*, the chin) of the mandible is situated about a half-inch above the margin of the mandible and about three quarters of an inch from its symphysis, and may sometimes be recognized by deep pressure with the tip of the finger; it is in line with the supraorbital and infraorbital foramina, and transmits the *mental nerve*, the terminal portion of the inferior dental nerve from the third division of the fifth. The **angle of the mandible** is easily palpated; the smooth, flat elevation just in front of it corresponds with the extent of the **masseter muscle,** immediately in front of the anterior margin of which, close to the border of the body of the mandible, the **facial artery** may be compressed, this being the point where this vessel passes from the neck to the face.

The prominence of the cheek is produced by the **malar bone**, the **zygomatic process** of which may be followed backward to its junction with the **zygomatic process** of the temporal bone, forming the **zygomatic arch.** The **neck of the condyle of the mandible** may be felt just below the front part of the zygomatic arch when the jaw of the living subject is depressed.

DISSECTION.

As a preliminary to the dissection of the face, the vestibule of the mouth, *i.e.*, the space bounded internally by the teeth and gums and externally by the cheeks and lips, should be moderately stuffed with oakum or cotton and the lips should then be stitched together. A median incision should be made over the forehead and along the nose to its tip. A second incision should be made transversely along the top of the forehead curved downward to the upper part of the ear. An incision should also be made along the free edge of each eyelid, the edges of

the eyelids having been first stitched together. The reflection of the skin-flap should be begun at its upper, inner angle and carried downward toward the upper eyelid and the root of the nose. At this stage the flap should not be reflected farther than the middle of the nose and the lower margin of the orbit, the lower part of the face being protected from drying by damp cloths. As the dissector reaches the upper eyelid he will find that the skin becomes very thin and that the work must be done with great care. After completing the upper eyelid he should begin at the inner extremity of the lower lid and remove the skin to the point indicated above. The orbicularis palpebrarum muscle is thus exposed, covered by a variable amount of connective tissue and fat (Fig. 164).

The **superficial fascia** of the face is somewhat peculiar in the fact that it is closely related to the facial muscles with which it is intermingled, these muscles having for the most part their insertions into the integument, the origins being either from the deep fascia or from bony surfaces. The nerves and blood-vessels found in the superficial fascia will be dealt with as the dissector encounters them in the various stages of his work. The **supraorbital nerve** and **artery,** the **supratrochlear nerve** and the **frontal artery** have already been considered in the dissection of the scalp. In the region thus far exposed the only other nerves and vessels to be considered are the **infratrochlear nerve,** a branch of the nasal nerve, which emerges from the orbit at the inner canthus and assists in supplying the skin of the side of the nose; the **angular artery** or termination of the facial artery found in the same locality; the **angular vein,** likewise found at the inner canthus and which establishes a communication between the ophthalmic vein and the facial vein; the **superior** and **inferior palpebral branches of the ophthalmic artery** which pass along the free edges of the upper and lower eyelids respectively; and some branches of the cervico-facial division of the facial nerve which pass forward from the lateral region of the face to supply the orbicularis palpebrarum.

The Orbicularis Palpebrarum.—**Origin,** the nasal process of the superior maxilla and the crest of the larchrymal bone; **nerve-supply,** the facial nerve; **action,** to close the eyelids. This muscle presents the paler, more delicate **palpebral portion,** or that portion which corresponds with the extent of the eyelids, and the more highly colored and more robust **orbital portion,** which corresponds with the margins of the orbital aperture (Fig. 164).

The **corrugator supercilii,** a small muscle placed beneath the orbicularis, may be exposed by making a vertical incision over the inner third of the supraorbital ridge and extending slightly above the ridge and carefully dissecting up the fibres of the orbicularis. The corrugator will then be seen (Fig. 164) as a small, obliquely directed muscle, **arising**

from the internal angular process and being **inserted** into the skin and subcutaneous tissue. Its **nerve-supply** is the facial nerve; its **action** is to produce the vertical wrinkles of the forehead.

The **Tensor Tarsi** (Horner's muscle), a part of the orbicularis, may be exposed by cutting through the orbicularis and the tendo oculi and slightly displacing the lachrymal sac as shown below.

The **lachrymal sac** may be exposed by cutting carefully through the fibres of the orbicularis close to its inner extremity, which brings into view the **internal palpebral ligament** or **tendo oculi.** This ligament bifurcates externally to be attached to the fibrous plate of each eyelid. Grasping the ligament with tissue-forceps it may be cautiously incised, the outer portion being reflected outward, when the lachrymal sac comes directly into view. Making tense the reflected portion of the palpebral ligament, the dissector will detect a band or sheet of tissue passing from the deep surface of the ligament inward behind the lachrymal sac. This is the *reflected aponeurosis* of the tendo oculi. It is attached by its inner extremity to the crest of the lachrymal bone. Its deep surface is related with and gives attachment to Horner's muscle, the distal end of this muscle passing outward to be attached to the edge of each eyelid near the inner canthus.

The **aponeurosis** of the elevator of the upper eyelid (levator palpebræ superioris) expands beneath the fibres of the orbicularis and may be exposed by carefully removing the latter muscle.

The Levator Palpebræ Superioris.—**Origin,** the back part of the roof of the orbit; **insertion,** the upper eyelid by an expanded tendon; **nerve-supply,** the superior division of the third cranial nerve; **action,** to elevate the upper lid.

The **tarsal plate** or "cartilage," a plate of fibrous tissue curved over the convexity of the eyeball, presenting a straight edge along its free border and a convex edge at its attached border, is the tissue which gives firmness to the eyelid. It is connected with the upper margin of the orbit by a sheet of fibrous tissue which is continuous with the attached border of the plate and which is attached to the inner and outer margins of the orbit by the inner and outer palpebral or tarsal ligaments. The lower eyelid is, of course, devoid of the expansion of the levator palpebræ and presents a tarsal plate which is of a shape like that of the plate of the upper lid, but which is only about one half its width.

Having completed the dissection of the eyelids, the removal of the skin may be completed by making a vertical incision in front of the ear from the zygoma to the angle of the lower jaw—with care for the safety of the auriculo-temporal nerve and the superficial temporal artery—reflecting the skin-flap forward. Extreme care is necessary in removing the skin to avoid cutting or taking up the facial nerves and muscles with it; if the knife is kept close to the deep surface of the skin this can be ac-

complished. Immediately in front of the ear, the **facial branch** of the auricularis magnus nerve (Fig. 176) should be found passing upward and forward toward the zygoma in the subcutaneous fatty and connective tissue overlying the parotid gland.

The **branches** of this nerve to the skin of the parotid region (p. 350) should be followed and also those that perforate the deep fascia and enter the gland to communicate with branches of the facial nerve. Having isolated these nerves, all loose tissue should be removed, when a dense layer of fascia will be seen, the **parotid fascia,** its peculiar opalescent whiteness being due to the underlying parotid gland, the anterior limits of which latter will be more or less clearly evident. The **temporo-facial branches of the facial nerve** (Fig. 163) should be found emerging from the upper and anterior borders of the gland near the zygoma and somewhat lower and should be traced: the upper or **temporal branches** across the zygoma to the anterior and superior auricular muscles, the frontalis and the orbicularis palpebrarum and corrugator supercilii, respectively; the **malar branches** forward across the malar bone to the orbicularis palpebrarum at the outer angle of the orbit; the larger **infra-orbital branches,** forward, a finger's breadth below the zygoma, breaking up into *superficial branches* for the facial muscles between the orbit and the upper lip and *deep branches*, which will be traced later (p. 397). Just below these nerves, the **duct of the parotid gland, Stensen's duct,** runs horizontally forward a finger's breadth below the zygoma and in correspondence with a line from the lobe of the ear to a point midway between the angle of the mouth and the wing of the nose. Passing thus across the surface of the masseter muscle to its anterior border it curves around the latter and pierces the buccinator muscle and the mucous membrane of the mouth to terminate opposite the second upper molar tooth. In close relation with the beginning of the duct is usually a small detached portion of the parotid gland, the **socia parotidis** or accessory parotid. The duct is sometimes difficult to discover and may be cut inadvertently. Attention to the usual line of its course as indicated above and a few strokes of the knife parallel with this course will usually bring it to light.

That part of the **platysma** found upon the face should now be denuded, if this has not been done, that it may be followed to the angle of the mouth, and the **risorius muscle** (Fig. 164) should be recognized and cleaned and its *origin* in the masseteric fascia and *insertion* into the angle of the mouth noted. The platysma should then be cautiously removed.

The **branches of the cervico-facial division of the facial nerve** (Fig. 163) are to be found as they emerge from the lower anterior part of the parotid gland, these branches arising within the gland at the point of division of their parent trunk near the angle of the

mandible. The **buccal nerve,** the highest of these branches, passes forward and upward beneath the risorius to be distributed to the buccinator and the orbicularis oris. The **supramandibular branch** is to be traced forward and its branches to the facial muscles below the mouth are to be noted and followed. The **inframandibular branch** passes below the mandible to supply the platysma and to communicate with the superficial cervical branch of the cervical plexus (p. 351).

THE FACIAL MUSCLES.—The facial muscles, which are quite pale in color and delicate in texture, are for these reasons and also because of their being intermingled with fatty and connective tissue difficult to dissect (Fig. 164). The **orbicular muscle of the eyelids,** the **corrugator of the brow** and the **risorius** have been dissected, as have also the three small **auricular muscles** and the **occipito-frontalis**, which are grouped with the *muscles of expression*, as the facial muscles are often designated. As stated before, these muscles are all more or less intimately connected with the skin and it is for this reason that they control facial expression. They are all **innervated** by the facial or seventh nerve.

Beginning at the root of the nose, the small **pyramidalis nasi** muscle —which may be regarded as a prolongation of the frontalis (p. 319)— is to be denuded, the **frontal vein,** connected by the **nasal arch** with the opposite vein, being encountered in the process (Fig. 193). Narrow at the root of the nose, the muscle spreads out and becomes aponeurotic as it descends (Fig. 164) and blends with the compressor nasi, its **origin.**

The **compressor nasi** (Fig. 164) takes its **origin** from just above the incisive or myrtiform fossa of the maxilla (Fig. 160) and ascending over the wing of the nose spreads out into an aponeurosis which is attached to the cartilage and which blends with that of the muscle of the opposite side and with the pyramidalis. It compresses and pulls down the alæ of the nose. In dissecting this and the preceding muscle, the **lateralis nasi artery,** a branch of the facial, will be found ascending to the dorsum of the nose and the **facial artery** itself passing upward along the side of the nose.

The **external branch of the nasal nerve** (Fig. 163) should be found on the lateral surface of the nose as it emerges from the nasal cavity through the notch on the lower border of the nasal bone between the latter and the lateral cartilage to terminate in the skin of this region. It lies at first under the compressor nasi, which may be incised to expose it.

The **dilator naris anterior,** passing from the cartilage of the ala to the skin at the margin of the nostril; the **dilator naris posterior,** passing from the anterior margin of the outer surface of the body of the superior maxilla to the skin near the margin of the nostril, and the **compressor narium minor,** going from the alar cartilage to the skin at the tip of

the nose, are small and rather indistinct muscles, so rudimentary in many cases as to be scarcely recognizable.

The Levator Labii Superioris Alæque Nasi.—**Origin,** the nasal process of the maxilla; **insertion,** the alar cartilage and the skin of the ala of the nose and the skin and muscles of the upper lip. The **action** of this muscle is to express disdain and contempt by dilating the nostril and elevating the upper lip. This muscle is partly at the side of the nose and partly external to it. In dissecting it, the **angular vein** will be found upon its surface and the **angular artery,** the termination of the facial, traversing its substance. The posterior dilator is partly covered by it. The *depressor of the wing* of the nose must be examined at a later stage (p. 400).

The small zygomatici muscles, **zygomaticus major** and **zygomaticus minor,** pass downward and inward from the malar region toward the mouth, the lesser muscle being the more anterior. Both **arise** from the malar bone, but while the minor is **inserted** into the upper lip, the major is **inserted** into the angle of the mouth and outer extremity of the upper lip. The slight difference between their points of insertion is the traditional "step between a smile and a tear," the major being concerned in laughter and the minor in the expression of sadness. The zygomaticus minor is often absent; it is by some anatomists regarded as being a separated portion of the major.

The Levator Labii Superioris (proprius) (Fig. 164).—**Origin,** the lower margin of the orbit above the infraorbital foramen (maxilla and malar bones); **insertion,** the upper lip. The muscle is overlapped above by the orbicular muscle of the eyelids and is crossed obliquely by the facial vein and lower down by the facial artery, which latter, however, may pass under the muscle or pierce it. The **action** is the expression of grief by drawing up the upper lip. A part of the elevator of the angle of the mouth is to be seen at the outer side of this muscle and at a deeper plane. The muscle should now be cut below and reflected upward without disturbing the facial artery and vein or the underlying infraorbital artery and infraorbital plexus of nerves.

The Levator Anguli Oris (m. caninus).—**Origin,** the canine fossa just below the infraorbital foramen; **insertion,** the angle of the mouth (Fig. 164); **action,** to elevate the angle of the mouth. The muscle can scarcely be completely denuded at present on account of the intricate plexus of nerves, the infraorbital plexus, which lies upon it; the infraorbital artery is also superficial to it.

The Orbicularis Oris (Fig. 164).—The orbicular muscle of the mouth is a complex of muscular bundles from those muscles described as being inserted into the lips and of bundles of fibres commonly regarded as intrinsic. Of the former group, the buccinator muscle contributes the largest share, its upper and lower fibres partly decussating

at the angle of the mouth and partly passing into the lips without crossing or interlacement, while the muscles referred to above as being inserted into the angle of the mouth and of the upper lip, as well as those inserted into the lower lip (vide infra) are concerned to no considerable extent. The so-called proper lip fibres consist of three paired groups: the **incisivi superiores** or **incisivi labii superioris,** which arise from the incisive fossæ of the superior maxillæ and pass downward and outward to the angles of the mouth; the **depressor septi,** or **naso-labialis,** are attached to the cartilage of the nasal septum and passing downward from the two vertical ridges which include the philtrum (p. 390) between them; the **incisivi labii inferioris** arise from the alveolar border

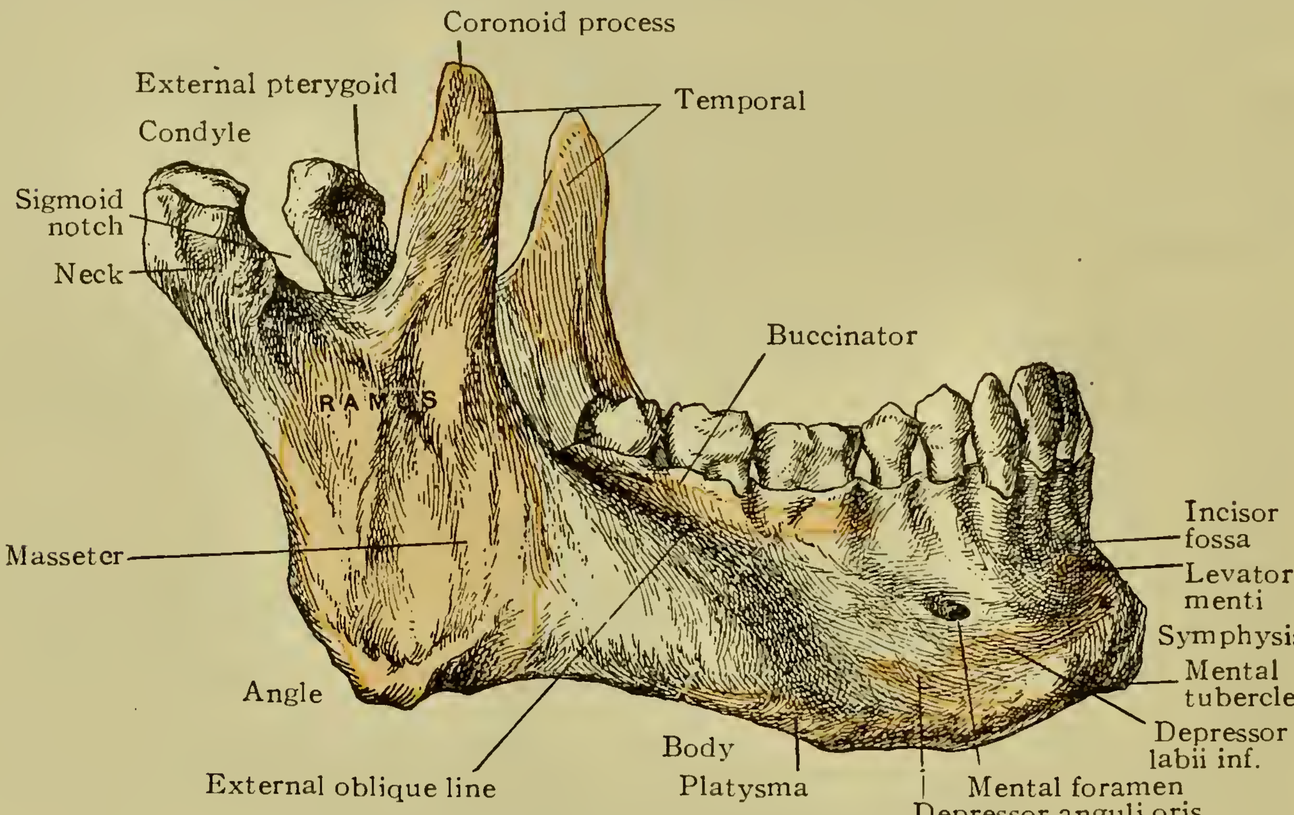

FIG. 190.—Inferior maxillary bone, outer aspect.

of the mandible below the canine teeth to pass to the angles of the mouth. The muscle is covered partly by skin and partly by mucous membrane and in many cases is quite difficult to expose satisfactorily, fat and connective tissue being intermingled with the muscle fibres and the latter being very pale. The coronary arteries run near the free margin of the lip between the mucous membrane and the muscle; to expose the vessels therefore it is necessary, when working from the cutaneous surface, to cut through the muscle fibres. In those cases where the muscular tissue is rather scant the arteries may appear as if placed rather upon than beneath it.

THE DEPRESSOR ANGULI ORIS OR TRIANGULARIS MENTI (m. triangularis) (Fig. 164).—**Origin,** the external oblique line of the mandible; **insertion,** the muscles and skin at the angle of the mouth; **action,** to depress the angle of the mouth, as in the expression of sorrow.

In cleaning the surface of this muscle, the branches of the mental nerve (Fig. 192) should be regarded as well as the branches of the submental artery; the inferior labial artery usually passes under it. The *musculus transversus menti* is a small transverse fasciculus of fibres sometimes found connecting the two muscles beneath the chin.

Depressor Labii Inferioris or Quadratus Menti (m. quadratus labii inferioris).—**Origin,** the external oblique line of the mandible internal to the preceding muscle; **insertion,** the skin and muscles of the lower lip; **action,** to depress the lower lip.

Being partly overlapped by the depressor of the lower lip the latter must be in part removed to expose this muscle (Fig. 164). It is crossed by the inferior labial artery.

Levator Labii Inferioris or Levator Menti (m. mentalis).—**Origin,** the incisive fossa of the mandible; **insertion,** the skin of the chin; **action,** to raise and protrude the lower lip.

This muscle is placed next the mucous membrane of the mouth and may be exposed by everting the lip and dissecting the mucous membrane; it may also be exposed by partial removal of the depressor of the lower lip.

The **risorius** has been dissected (p. 393).

The dissection of the **facial branches of the facial nerve** should now be completed; their points of exit from the parotid gland and their course and distribution have been sufficiently indicated (p. 393). The course of the facial nerve through the temporal bone (p. 454) and through the parotid gland (p. 401), its branches other than those to the muscles of expression (p. 455) and the effects of paralysis of the nerve (p. 456) will be studied subsequently.

The **subcutaneous malar plexus** will be found over the prominence of the malar bone. It is formed by the malar branch of the temporo-malar nerve from the superior maxillary division of the fifth, which leaves the orbit and reaches the surface of the malar bone through the orbital foramen, the temporal branch of the same nerve going to the temporal region (p. 319 and Fig. 163). Branches of the facial nerve communicate with this plexus.

The **deep branches** of the infra-orbital rami of the facial nerve (p. 393) should now be picked up and traced inward beneath the zygomatici to the infra-orbital plexus, which was encountered in the dissection of the levator anguli oris. Lying upon that muscle and covered by the levator labii superioris, the **infra-orbital plexus** is formed by the deep set of the infra-orbital branches of the facial, which supply the levator anguli oris, the levator labii superioris alæque nasi and the smaller nasal muscles, and **branches of the infra-orbital nerve,** the terminal part of the superior maxillary division of the fifth. The **infra-orbital nerve** gives off here three sets of branches, nerves of common sensation: the

palpebral branches pass up under the orbicularis palpebrarum to be distributed to the skin and conjunctiva of the lower eyelid (p. 431); the *nasal branches* pass inward to supply the skin on the side of the nose; the *labial branches* go downward beneath the elevator of the upper lip to supply the skin and mucous membrane of the upper lip (Fig. 192).

The **mental nerve**, one of the terminal branches of the inferior dental (p. 415), should now be picked up at its point of exit from the inferior dental canal through the mental foramen (Fig. 192), beneath the depressor of the angle of the mouth, and followed to its distribution; its *branches* supply common sensation to the skin and mucous membrane of the lower lip and to the skin of the chin.

The Facial Artery, Facial Portion.—The facial or external maxillary artery (p. 374) reaches the face at the anterior inferior angle of the masseter muscle and passes tortuously upward and inward to the inner angle of the orbit to terminate as the angular artery (Fig. 163); its course is indicated therefore by a **surface line** from a point on the lower border of the mandible about one and three fourths inches in front of its angle to the inner angle of the orbit. The **relations** of the vessel have practically been demonstrated in the foregoing dissection: the facial vein lies external to and at some little distance from the artery; the artery is *covered* by the skin and fascia, including the fat, and successively by the platysma, risorius, zygomatici and sometimes by the elevator of the upper lip, its terminal portion traversing the bundles of the elevator of the upper lip and wing of the nose, and is crossed by branches of the facial nerve and by the inferior labial vein. It *lies first upon* the body of the mandible, at the anterior border of the masseter where its pulsations may be felt and where it may be compressed against the bone to control hemorrhage, then in succession upon the buccinator, the levator anguli oris and the levator labii superioris, unless it passes over the last named muscle.

The **branches upon the face** are the *inferior labial*, the *inferior coronary*, the *superior coronary*, the *lateralis nasi*, the *angular* and the *muscular*. The exposure of the artery should now be completed by the removal of any remaining connective tissue and fat and of those muscles which cross it.

The **inferior labial branch** should be traced beneath the depressor anguli oris to the lower lip and its anastomoses with the mental, submental and inferior coronary noted. The **inferior coronary** is to be traced beneath the depressor anguli and orbicularis oris and in its course between the latter muscle and the mucous membrane of the lip, noting its inosculations with the inferior coronary, with the submental and inferior labial branches of the facial. The **superior coronary** when followed is seen to sustain relations similar to those of the inferior coronary; its *branches* are the *inferior septal artery*, which passes upward to

the fore part of the nasal septum and anastomoses with the naso-palatine branch of the internal maxillary, and the *artery of the ala*, which goes to the wing of the nose. The **lateralis nasi,** arising at the ala of the nose and passing to its dorsum, has been dissected (p. 394); it anastomoses with the nasal branches of the superior coronary, with the infra-orbital and with its fellow. The **angular artery,** the terminal part of the facial, passes through the levator labii superioris alæque nasi in close proximity to the angular vein and on the inner side of the lachrymal sac and anastomoses with the nasal branch of the ophthalmic.

The very free anastomoses of the facial artery explain the profuse bleeding that occurs in wounds of the face and also the uselessness of compression or ligation of the vessel at the margin of the mandible to control such bleeding; it is also an explanation of the readiness with which wounds of the face heal if properly protected. *Hemorrhage from a wound of either lip* may be controlled by grasping the entire thickness of the lip on both sides of the wound between the thumbs and forefingers or by sutures or acupressure pins including the whole thickness of the lip except the mucous membrane.

The Anterior Facial Vein or Facial Vein.—This vein and most of its tributaries have been exposed in the dissection of the structures thus far worked out, so that it only remains to complete the denudation in such places as may be necessary. The anterior facial vein **originates** near the inner canthus in the angular vein. The **angular vein** is formed by the union of the supraorbital vein (p. 427) and the frontal vein. The **frontal vein,** found near the mid-line of the forehead, arises from the venous plexus of the scalp and communicates with its fellow at the root of the nose by the short **transverse nasal arch** (v. nasofrontalis).

The **angular vein,** receiving tributaries from the upper lid (superior palpebral veins) and from the nasal region, forms an important communication with the ophthalmic vein (p. 427) and then continues as the anterior facial vein. The *course* of the anterior facial vein from the inner canthus to the lower border of the body of the mandible at the anterior margin of the masseter is a more direct one than that of the facial artery, the vein being external to the artery. It passes beneath the zygomatici and, after leaving the face, crosses the submaxillary gland and unites with the anterior trunk of the temporo-maxillary vein to form the common facial vein (p. 365). Its **tributaries** are the *inferior palpebral*, the *superior* and *inferior labial*, the *buccal*, the *masseteric* and, most important of all, the *deep facial* or *anterior internal maxillary vein*, from the pterygoid plexus (Fig. 193); the latter emerges from beneath the anterior border of the masseter to reach the anterior facial vein. The anterior facial vein has no valves.

The clinical importance of the connections of the facial vein with the cavernous sinus through the communication between the angular and ophthalmic veins and through the deep facial and pterygoid plexus and the basal emissary veins has been pointed out (p. 335).

The Depressor Alæ Nasi (Fig. 164).—**Origin,** the incisive fossa of the superior maxilla; **insertion,** the septal cartilage and the back part of the alar cartilage of the nose; **action,** to draw the ala downward and thus to constrict the aperture of the nostril. This muscle and the compressor nasi are sometimes described as one muscle, the **nasalis.** The muscle is beneath the orbicularis oris; the latter must therefore be cut to expose it.

The Buccinator Muscle.—**Origin,** the outer surfaces of the alveolar processes of the superior maxilla and the mandible to an extent corresponding to the three molar teeth and the anterior border of the pterygo-maxillary ligament (Fig. 197); **insertion,** the orbicularis oris, the highest and lowest fibres passing to the upper and the lower lip respectively, while the intervening fibres decussate; those from the mandibular origin passing to the upper lip and those from the maxilla going to the lower lip. **Action,** to assist in keeping the food between the teeth during mastication (vide Bell's palsy, p. 456) and to expel air from the mouth as in blowing a trumpet. **Nerve-supply,** the buccal branch of the facial nerve.

To expose this muscle the facial artery and vein, the buccal branch of the facial nerve and the buccal branch of the inferior maxillary division of the fifth must be displaced or removed, as must also the large pad of fat which is tucked in between the outer surface of the muscle and the deep surface of the masseter. In removing the fat, regard the parotid duct, which perforates the muscle (p. 393).

The **sucking pad** (corpus adiposum buccæ), the pad of fat referred to above, is relatively larger in infants than in adults and is said to be of service in the act of sucking by assisting the cheek to resist atmospheric pressure from without, though how it can do this seems difficult to understand. It would seem more probable that its purpose is to serve as an elastic cushion to protect the nerves and vessels beneath it, *e.g.*, the long buccal nerve, from undue compression by the powerful contractions of the masseter and buccinator during mastication.

The **bucco-pharyngeal fascia** covers the outer surface of the buccinator. At the posterior limit of the muscle the fascia is thickened to form the **pterygo-mandibular ligament** (p. 417) and is continued over the surface of the superior pharyngeal constrictor which has part of its origin from this ligament (Fig. 197).

The outer surface of the buccinator can be more fully examined after the removal of the masseter; its inner surface is covered by the buccal glands and the mucous membrane of the mouth.

The Parotid Gland (glandula parotis).—The parotid, the largest of the salivary glands, is **situated,** as its name implies, near the external ear; more specifically, it rests in part upon the outer surface of the masseter to a variable extent, its posterior limit being the external auditory

meatus, its upper limit the zygoma and its lower limit the angle of the mandible and a line prolonged from the latter to the mastoid process; it slightly overlaps the sterno-mastoid behind and the posterior belly of the digastric below. Being prolonged inward behind the posterior border of the ramus of the mandible (*processus retromandibularis*) it extends forward upon the inner side of the latter between the internal and external pterygoid muscle (*pterygoid lobe*), inward behind the styloid process and beneath the mastoid process and inward in front of the styloid process to occupy the non-articular part of the glenoid fossa (*glenoid lobe*). The **socia parotidis** or **accessory parotid gland** has been examined, as has the **duct** (p. 393) (Figs. 176 and 178).

The gland is enclosed within a layer of fascia, the **parotid fascia,** a part of the deep cervical fascia, which forms a bag-like sheath or capsule for the gland. The part of this fascia on the outer surface of the gland, the *superficial layer*, is extremely dense; it is attached above to the zygoma and is continuous behind and in front respectively with the fascia covering the sterno-mastoid and with the masseteric fascia, being continuous below with the deep layer. The *deep layer* of the parotid fascia is relatively thin; it is attached to the styloid process and is continuous with the stylo-mandibular ligament and the fascial sheaths of the pterygoid muscles. Treves points out that the gland is enclosed thus in a distinct fascial sac which is closed below but open above and that this sae is in communication with the retro-pharyngeal space through an interval between the anterior border of the styloid process and the posterior border of the internal pterygoid muscle, and also that the deficiency of the deep layer of the sac above permits the gland to come into direct relation with the cartilaginous part of the external auditory canal.

The Structures which Traverse the Parotid Gland.—The parotid fascia should now be removed from the surface of the gland by severing its attachment to the zygoma and reflecting it, observing to avoid injury to the branches of the facial nerve already dissected. A transverse incision through the gland about a half inch below the zygoma should bring to light the **transverse facial artery,** a branch of the superficial temporal artery or occasionally of the external carotid. The several **branches of the facial nerve** previously isolated should be traced one after another through the gland substance—incising the latter to the necessary extent—to their parent trunk, the facial (p. 393).

The **facial nerve,** upon leaving the stylo-mastoid foramen, curves forward and downward around the outer side of the styloid process and above the posterior belly of the digastric, and entering the gland, crosses the external carotid artery and the temporo-maxillary vein superficially and breaks up into the *temporo-facial* and *cervico-facial divisions* (p. 393). The **communicating branches of the auricularis magnus** may be followed into the gland to their points of connection with the facial nerve.

The **external carotid artery** should be sought in the deep interval between the posterior border of the ramus of the jaw and the mastoid process, the temporo-maxillary vein being on its outer side, except above, where it is superficial to the artery. The external carotid enters the deep surface of the gland opposite the junction of the middle and lower thirds of the posterior border of the ramus of the jaw. Traced upward to the level of the neck of the condyle, it divides into its **terminal branches,** the *superficial temporal,* which after giving off the transverse facial branch (p. 401) quits the gland at the zygoma (p. 318), and the *internal maxillary,* the larger, which leaves the gland to pass forward between the ramus of the jaw and the internal ligament. The intra-glandular portion of the external carotid is separated from the internal carotid by the deep part of the gland, since the latter vessel passes beneath the gland.

The **temporo=maxillary vein** arises near the neck of the condyle of the mandible by the union of the *internal maxillary* and the *common temporal veins,* the latter receiving as its **tributaries** the rather large *transverse facial vein,* in addition to small *glandular, articular* and *anterior auricular veins.* The temporo-maxillary vein descends through the gland externally to the external carotid and divides into an *anterior* and a *posterior trunk* (pp. 349 and 365).

The **auriculo=temporal nerve,** a branch of the inferior maxillary division of the fifth (p. 414), enters the gland at the inner side of the neck of the condyle of the mandible and passes upward over the zygoma with the superficial temporal artery (p. 318). Its **branches** in this region are one or two *communicating branches* which arise near the condylar neck and pass forward to join the facial near the posterior border of the ramus; *parotid branches* to the gland; *articular* to the temporo-mandibular joint; *anterior auricular* to the pinna and a *branch* to the skin of the external auditory meatus; its *temporal branches* have been dealt with (p. 318).

A few lymph-nodes are found within the gland along the course of the temporo-maxillary vein.

The **relations of the parotid gland** may be summarized: *Within* the gland are the external carotid, superficial temporal, internal maxillary and transverse facial arteries; the temporo-maxillary, common temporal, internal maxillary and transverse facial veins; the facial and temporal nerves and some branches of the great auricular nerve. *Beneath* the gland are the internal carotid artery, the internal jugular vein, the pneumogastric, glosso-pharyngeal and hypoglossal nerves; on its *inner side* are the styloid process, the stylo-pharyngeus, the stylo-glossus, the stylo-maxillary ligament and the internal pterygoid muscle; *behind,* the sterno-mastoid, the mastoid process, the external auditory canal, the tympanic plate, the base of the styloid process and the atlas.

The **blood-supply** is derived from the arteries that traverse the gland and from the posterior auricular.

The **innervation** is effected by the facial, auriculo-temporal, great auricular and the sympathetic plexus of the external carotid (derived from the superior cervical ganglion); possibly from the tympanic plexus of the glosso-pharyngeal through the small superficial petrosal to the otic ganglion and thence through the auriculo-temporal.

The denseness of the superficial layer of the parotid fascia is a barrier to the approach of pus to the surface in **parotid abscess**; the weakness of the deep layer and the open condition of the sac above, facilitate the extension of pus into the temporal and zygomatic fossæ and into the deeper parts of the neck or its invasion of the external auditory canal or of the temporo-mandibular joint, while the gap in the sac between the styloid process and the internal pterygoid muscle allows it to travel to the retro-pharyngeal space. The presence of the important structures within the gland is a reason for caution in incising a parotid abscess, *Hilton's method of incision* being recommended.

The **relations** of the gland as seen above make its entire removal an impossible procedure.

Parotitis or **inflammation of the gland** sometimes occurs after specific fevers. The special form of parotitis known as *mumps* is of frequent occurrence; its tendency to be complicated with inflammation of the testis or ovary is well known but inexplicable on anatomical grounds; the same may be said of the fact that the parotid and the testis are both noteworthy among soft tissues for their liability to *enchondroma*.

The **parotid duct** (p. 393) is sometimes cut in wounds of the face; the escape of saliva through the wound interferes more or less with the healing process and *salivary fistula* is apt to result.

The superficial or facial portion of the parotid may now be removed to expose the masseter.

THE MASSETER (Fig. 191).—*Superficial portion*: **origin,** the malar process of the superior maxilla and the anterior two thirds of the lower border of the zygoma; **insertion,** the angle and the lower half of the outer surface of the ramus of the mandible. *Deep portion*: **origin,** the posterior third of the lower border and the entire inner surface of the zygoma; **insertion,** the outer surface of the coronoid process and the upper half of the ramus of the mandible. **Action,** to draw the mandible upward and forward. **Nerve-supply,** the masseteric branch of the anterior trunk of the mandibular division of the fifth nerve.

The masseter is one of the muscles of mastication. The muscle is covered by the **masseteric fascia,** which should be removed by detaching it from the zygoma; the fascia is continuous with the deep cervical fascia; over the muscle it is rather dense, adhering closely to the latter, but thins out in front. The superficial portion of the muscle having been cleaned, it may be removed by cutting its tendinous origin and turning it downward. The deep portion should then be similarly cut, with care to avoid the temporo-maxillary joint, and should be reflected slowly and carefully that the **masseteric nerve** and **artery** may be found

as they pass outward across the sigmoid notch of the mandible to reach the deep surface of the muscle. Its removal—the nerve with a fragment of muscle should be preserved—exposes the posterior part of the buccinator, the long buccal nerve, the sucking pad of fat, the insertion of the temporal muscle, the ramus of the mandible and the outer aspect of the temporo-mandibular joint.

THE PTERYGO-MAXILLARY REGION.—The pterygo-maxillary region includes the zygomatic fossa and the region bounded externally by the ramus and the back part of the body of the lower jaw and internally

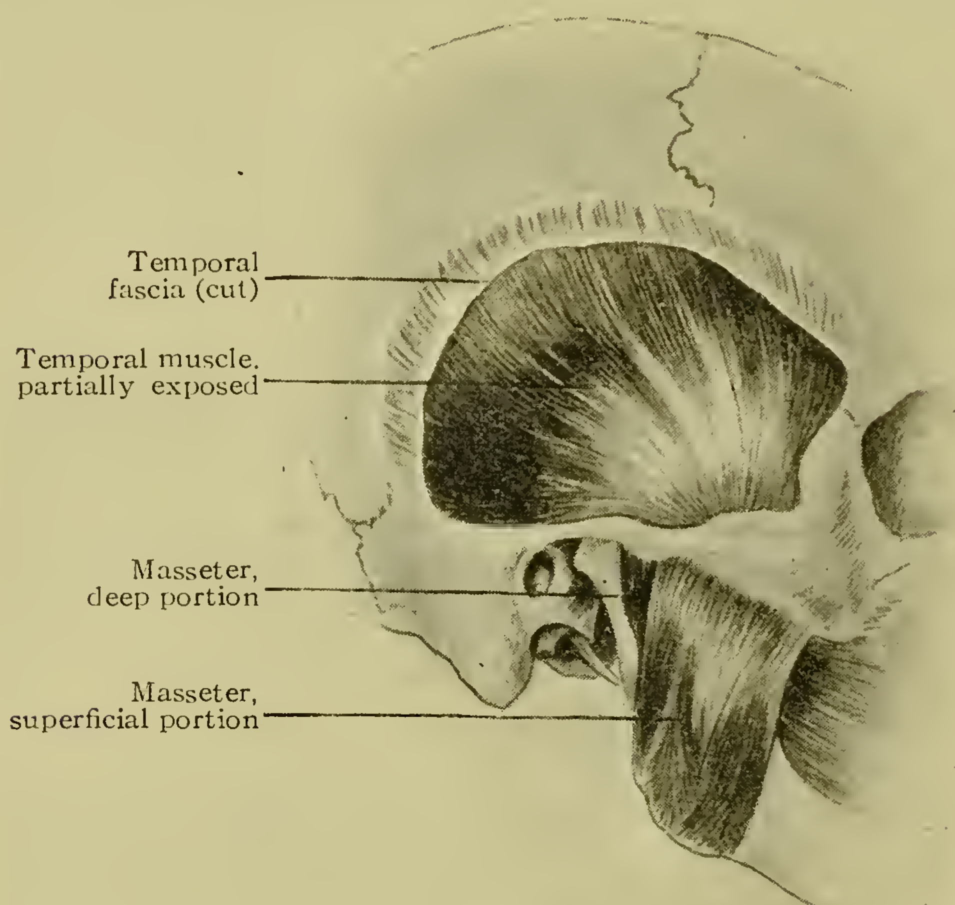

FIG. 191.—Right temporal and masseter muscles.

by a portion of the lateral aspect of the pharynx. It is to be exposed by the removal of the ramus of the mandible as directed below. It is desirable to examine the temporo-mandibular joint superficially, however, before disturbing the lower jaw.

THE TEMPORO-MANDIBULAR ARTICULATION (articulatio mandibularis) (Fig. 191).—The **bony surfaces** involved in this **ginglymo-arthroidial** joint are the anterior (squamosal) part of the glenoid cavity, the articular eminence and the condyle of the mandible. The **ligaments** are the *interarticular cartilage* or *meniscus*, the *capsular*, the *external lateral*, the *internal lateral* and the *stylo-mandibular*. **Blood-supply,** the superficial temporal artery; **nerve-supply,** the auriculo-temporal and masseteric nerves.

The **external lateral ligament** (lig. temporomandulare) is attached above to the outer surface of the zygoma and the tubercle on its lower border and below to the outer surface and posterior border of the neck of the mandible (Fig. 162). This ligament is a thickened part of the capsule. It should be cleaned as well as the present stage of the dissection will permit.

The **stylo-mandibular ligament** is merely a part of the deep cervical fascia passing from the styloid process of the temporal bone near its apex to the angle and the adjacent part of the posterior border of the ramus of the mandible (p. 374). It is merely an accessory ligament.

The **internal lateral ligament** (lig. sphenomandibulare) passes from the spinous process of the sphenoid to the lingula and margin of the dental foramen of the mandible (Fig. 217). It is broader below than above. Its outer surface, at its upper part, is separated from the joint by the insertion of the external pterygoid muscle (Fig. 217) and below this the internal maxillary artery passes between it and the neck of the condyle; still lower it is separated from the ramus by the inferior dental nerve and vessels. Its inner surface is in relation with the internal pterygoid muscle. This ligament is mentioned here as a matter of convenience; the dissector will examine it a little later.

The **capsular ligament** is thin and lax and is attached above to the margin of the glenoid cavity and the articular eminence, below to the neck of the condyle and between these points to the periphery of the interarticular cartilage. Its inner part is sometimes described (Humphry) as the *short internal lateral ligament.*

The **interarticular cartilage** (discus articularis) is an oval plate, its concave inferior surface being adapted to the convexity of the condyle, its superior surface being concavo-convex fore and aft to adapt it to the convexity of the articular eminence and the concavity of the glenoid fossa, and somewhat convex from side to side. Its circumference gives attachment to the capsular ligament and its anterior margin receives part of the insertion of the external pterygoid. It usually divides the joint into two distinct cavities, each provided with its own synovial membrane. Occasionally the discus is perforated, allowing the cavities to communicate. This also will be examined at a subsequent stage of the work.

The **movements** of the joint are somewhat complex, the *antero-posterior movement* occurring between the articular disk and the glenoid cavity and articular eminence, and the *ginglymoid* or hinge-like movement between the articular disk and the condyle. In the former case, the condyle and disk move forward, the disk gliding onto the articular eminence, the attachment of the external pterygoid to the disk as well as to the neck of the condyle, causing them to act almost as a unit; in the latter case, the condyle rotates about a transverse axis, passing prac-

tically through its point of contact with the disk. The mandible is *elevated* by the action of the temporal, the masseter and the internal pterygoid; *depressed* by its own weight, aided by the platysma, digastric, mylo-hyoid, genio-hyoid and the depressors of the hyoid bone; *drawn forward as a whole* chiefly by the simultaneous action of both external pterygoids, but aided by the superficial portion of the masseter and the internal pterygoid; *drawn backward* by the deep portion of the masseter and the posterior fibres of the temporal; the external pterygoid of one side acting alone shoves the chin forward and to the opposite side.

The relation of this joint to the parotid gland (p. 402) accounts for the great pain which attends movements of the jaw in inflammatory conditions of the gland.

Luxations of this joint are nearly always in the forward direction and are more frequently bilateral than unilateral. They may be caused by violence, as a downward blow on the front of the mandible with the mouth wide open, or by muscular action, as in yawning or violent vomiting. In the dislocation, the condyle and discus pass upon the articular eminence, the condyle continuing forward to the zygomatic fossa while the discus remains behind. The upward pull of those muscles which elevate the jaw (see above) fixes the condyle in this position and resists reduction; hence the common practice of overcoming this resistance by downward pressure on the mandible in the region of the molar teeth by the surgeon's thumbs placed in the patient's mouth for this purpose. It has been shown that the contact of the coronoid process with the malar bone is the obstacle to reduction in some cases.

The external lateral ligament (p. 405) passes downward and backward to its attachment to the mandible; the larger superficial portion of the masseter passes downward and backward, as does also the internal pterygoid muscle, while the external pterygoid passes almost horizontally backward and outward; these facts doubtless explain the relatively rare occurrence of *backward dislocation.*

Owing to the proximity of the joint to the middle ear and the external auditory canal, suppurative conditions of these parts sometimes involve the joint; because of the same relationship the middle ear and the canal may be damaged by backward dislocation.

The zygomatic arch should be divided near its root, just in front of the attachment of the external lateral ligament and also at its anterior extremity. Pass a grooved director under the back part of the arch to define its free portion and after partially dividing the bone with the saw, complete the division with bone-pliers; divide the anterior portion of the arch in the same way and remove the segment. The lower part of the temporal muscle (p. 321) may be examined, its superficially placed tendon being noted. Partly sawing and partly cutting off the base of the coronoid process, with due regard for the long buccal nerve and the buccal artery, and turning the temporal muscle upward, the nerves and vessels passing into its deep surface may be noted. The **temporal branch** of the temporo-malar nerve emerges from the orbit through the foramen near the center of the temporal surface of the malar bone and perforates the muscle to reach the skin of the temporal region (Fig.

163). Two or three **deep temporal nerves,** branches of the anterior division of the inferior maxillary nerve, enter the deep surface of the muscle, a small *posterior one* at the back of the fossa, an *anterior branch,* often arising from the buccal nerve, at the front of the fossa, and sometimes a *middle branch.* The two or three **deep temporal arteries** from the second portion of the internal maxillary are also to be recognized.

The ramus of the mandible is now to be removed in part. Divide the neck of the condyle below the insertion of the external pterygoid, using

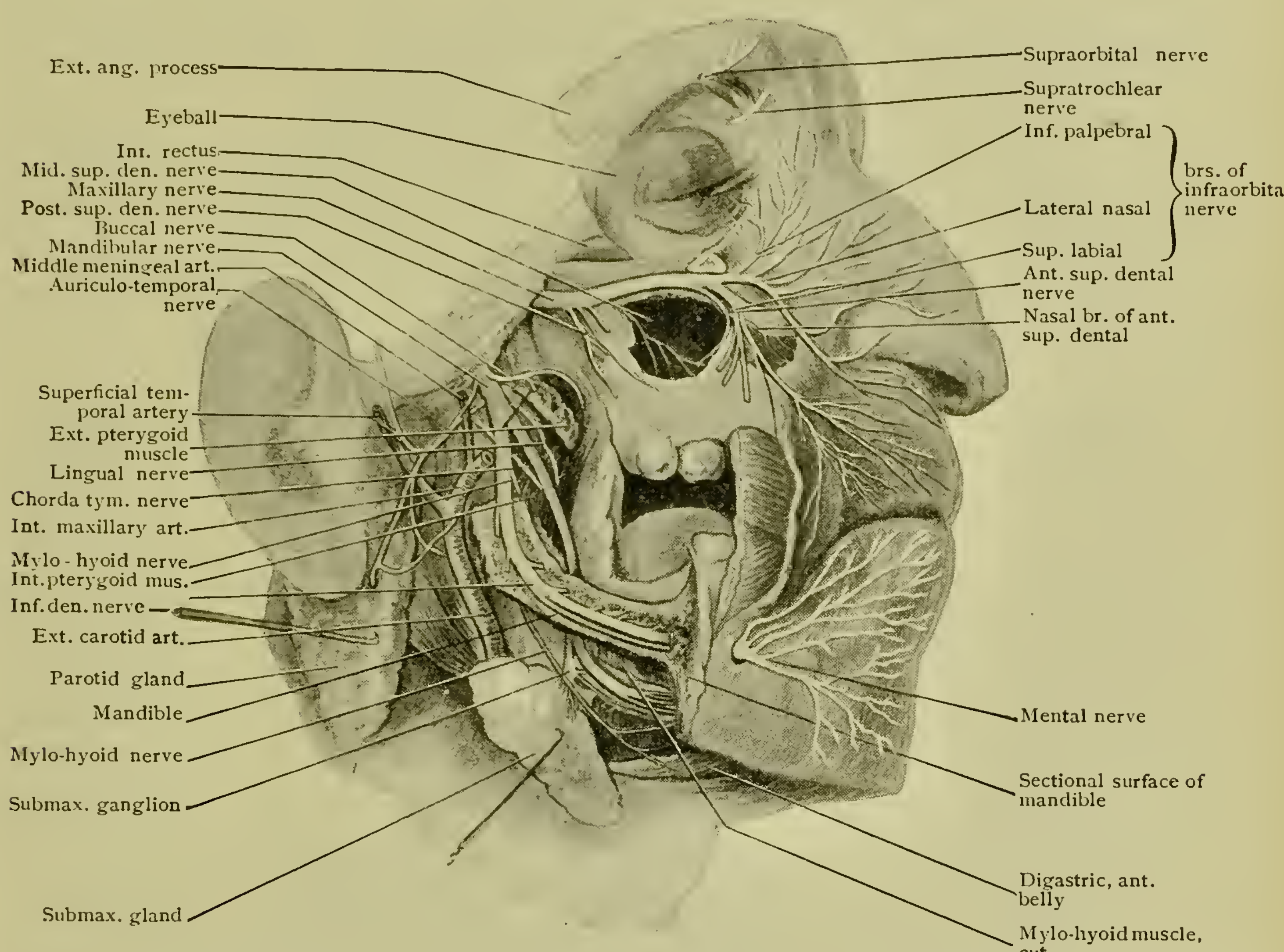

FIG. 192.—Dissection of maxillary and mandibular nerves; outer wall of orbit, part of outer wall of maxillary sinus and part of mandible have been removed.

a small saw at first and completing the section with the bone-pliers. Extreme care is necessary to avoid laceration of the vessels and nerves in relation with the joint and with the ramus. The ramus of the bone is to be divided slightly above the level of the entrance of the inferior dental nerve and artery into the dental canal. This point may be determined by passing a probe or director from behind the posterior border of the ramus forward along the upper part of the inner side, the instrument hugging the bone to insure its passage between the latter and the nerve and vessels; the point at which the instrument is arrested when depressed as a whole will indicate the point of entrance of the structures

into the foramen. After applying the saw at this level and sawing through the outer two thirds of the thickness of the bone, the saw may be abandoned for the pliers.

The background of the region thus exposed is constituted by the internal and external pterygoid muscles chiefly, the internal maxillary artery and vein and the inferior dental nerve and vessels being also conspicuously in evidence. The external pterygoid is the muscle above and its fibres are more nearly horizontal in direction than those of the internal pterygoid, which is lower and more internal. All loose fat and connective tissue are to be removed, the dissector being constantly on the watch for small nerves and vessels.

The **masseteric nerve** was found as it crossed the sigmoid notch of the mandible, between the joint and the tendon of insertion of the temporal muscle to reach the masseter (p. 403). Trace this nerve toward its origin, following it over the outer surface of the external pterygoid muscle to the upper border of the latter; it usually gives a *branch* to the temporal muscle and sometimes an *articular filament* to the joint (Fig. 192).

The **buccal nerve,** already recognized (p. 400), should be picked up as it crosses the outer surface of the external pterygoid or emerges from between its two heads and followed forward to the surface of the buccinator, the **buccal artery** which accompanies it being also dissected. So much of the **internal maxillary artery** and **its branches** as may be accessible should be denuded, the artery being followed to the interval between the two heads of the external pterygoid or over the outer surface of that muscle to the pterygo-maxillary fissure. The denudation should be effected by pinching up the connective tissue from its surface, keeping watch for the branches and for related nerves. The **internal maxillary vein** should be treated in like manner; its numerous tributaries will be poorly represented unless the veins have been specially injected, but they should be preserved to as great an extent as possible. The **inferior dental nerve** and **artery,** easily identified by their entrance into the dental foramen, the *mylo-hyoid branch* of each given off near the foramen (Fig. 192) not being overlooked, should be picked up from the surface of the internal pterygoid and followed upward, the artery to the internal maxillary, the nerve to the lower border of the external pterygoid muscle. The **lingual nerve** will be found a little way in front of the inferior dental and should be followed upward to the lower border of the external pterygoid from under which it emerges.

The Internal Maxillary Vein and The Pterygoid Plexus (Fig. 193).—The internal maxillary vein **originates** in the venous plexus formed by the veins corresponding to the branches of the internal maxillary, and **terminates** in the parotid gland by joining the common temporal vein to form the temporo-maxillary vein. Its **tributaries** are those indicated

below (see p. 411 for branches of the internal maxillary artery). The **pterygoid plexus** (Fig. 193) lies upon the outer surface of the external pterygoid muscle and between the external and internal pterygoids, the latter portion sometimes appearing as a distinct and larger plexus.

The importance of the pterygoid plexus centres in its communications with other venous trunks. Thus, through the deep facial vein (p. 399) it communicates with the venous circulation on the face and through the tributaries coming from the

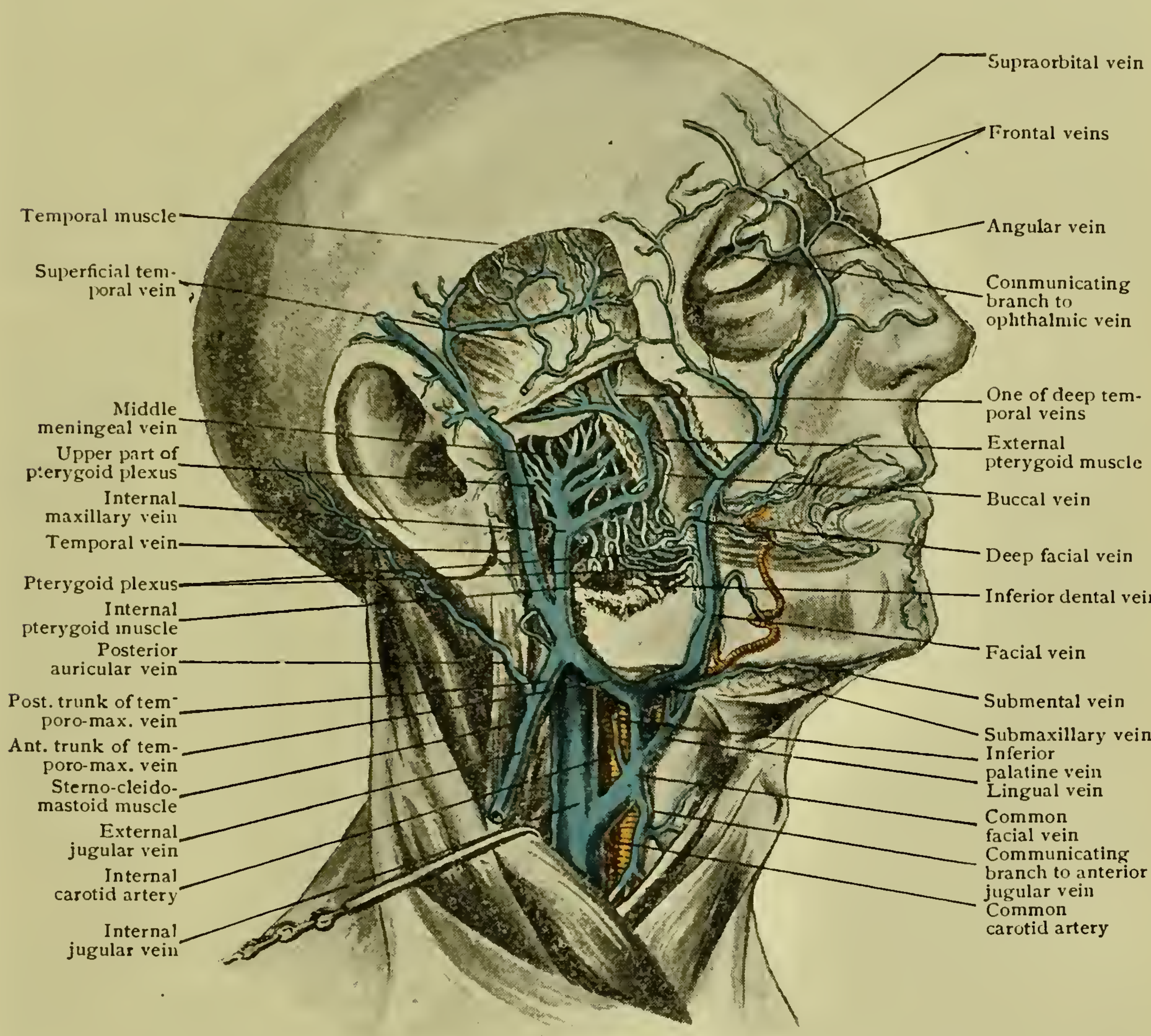

Fig. 193.—Veins of head; part of mandible and associated muscles have been removed to expose pterygoid plexus.

skull, the small and great meningeal veins and the emissaries that leave the skull through the foramina ovale, Vesalii et lacerum medium (p. 337) with the intracranial circulation; receiving the spheno-palatine veins from the nasal cavities and the superior dental veins, it constitutes an important link in the chain connecting the cavernous sinus with the veins of the regions designated. Its part in the conveyance of septic material has been indicated (p. 335).

The veins may be now removed and attention given to the relations of the structures as they appear at this stage of the dissection.

The External Pterygoid Muscle (m. pterygoideus externus) (Fig. 192).—**Origin,** the *upper head*, the zygomatic surface of the great wing of the sphenoid and the pterygoid ridge or infratemporal crest; the *lower head*, the external surface of the pterygoid plate; **insertion,** the pterygoid fossa on the front of the condylar neck of the mandible and the front of the discus articularis; **action,** of the two muscles at once, to draw the jaw and the discus forward; of one muscle alone, to thrust the chin to the opposite side; **nerve-supply,** the external pterygoid branch of the anterior trunk of the mandibular division of the trifacial. **Relations,** by its *outer surface* with the ramus and the coronoid process of the mandible, the tendon of the temporal muscle, the buccal nerve and artery, and frequently, its lower head, the internal maxillary artery; by its *inner surface*, with the internal pterygoid, the spheno-mandibular ligament, the mandibular, lingual, chorda tympani and inferior dental nerves, the internal maxillary and middle meningeal arteries.

Having noted the direction of the fibres and the relations of the outer surface of the muscle, it is to be reflected forward by enucleating the condyle of the mandible from its capsule, incising the capsule above the discus that the latter may be removed with the condyle. In doing this, avoid injuring the internal maxillary artery and the auriculo-temporal nerve on the inner side of the joint as well as the muscular and other branches of the mandibular nerve already dissected. If the artery passes in this case over the outer surface of the muscle instead of under it, the muscle may be cut in such manner as to leave undisturbed the portion that supports the vessel, or the muscle may be left in position until the artery has been studied. The relation of the interarticular cartilage to the condyle and to the insertion of the external pterygoid may be examined by cutting the part of the capsular ligament that encloses the inferior cavity of the temporo-mandibular joint (p. 405).

The Internal Maxillary Artery.—The internal maxillary **arises** as one of the terminal branches of the external carotid opposite the neck of the mandible; passing tortuously, at first forward, and then upward and inward, after going between the two heads of the external pterygoid muscle, it enters the spheno-maxillary fossa through the pterygo-maxillary fissure and **terminates** by dividing into the *infraorbital* and *alveolar arteries*. The infraorbital artery is by some regarded as the continuation of the internal maxillary, while others look upon the spheno-palatine branch as representing the continuation of the parent trunk.

The **first** or **maxillary** or **mandibular portion** of the vessel (Fig. 194) extends from its origin to the point where it passes either upon or beneath the external pterygoid muscle. This portion of the vessel passes horizontally forward and inward. It is **related** on its outer side with the ramus of the jaw, and on its inner side with the spheno-mandibular lig-

ament, while the auriculo-temporal nerve and the lower border of the external pterygoid muscle are above and parallel with it. The inferior dental nerve crosses its course at right angles, passing under it, as does the lingual nerve unless the artery curves upward to pass beneath the external pterygoid before reaching the lingual nerve.

The **branches** are the *deep auricular*, the *anterior tympanic*, the *great* or *middle meningeal*, the *small meningeal* and the *inferior dental.*

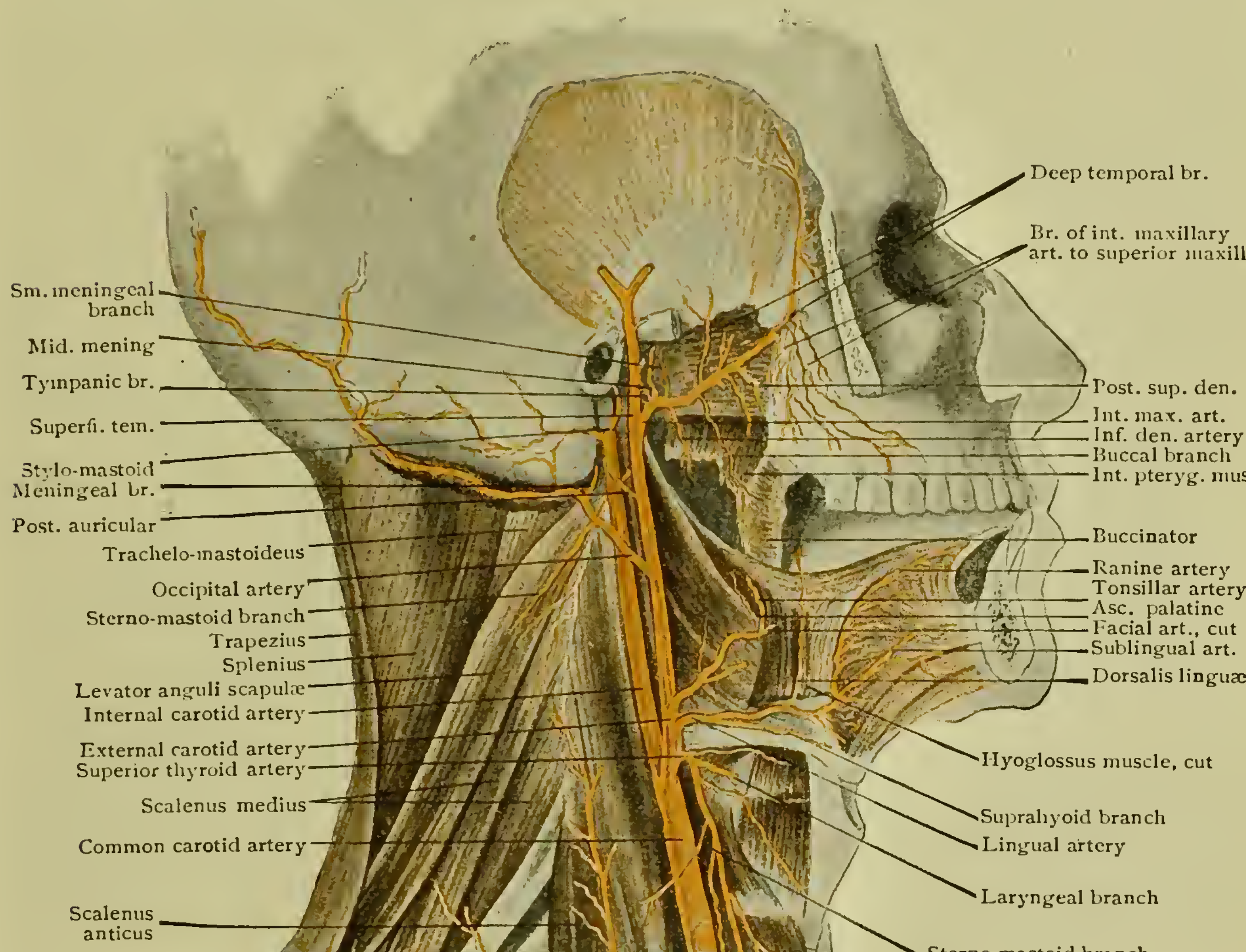

FIG. 194.—Dissection of arteries of upper part of neck and pterygo-maxillary region.

The **deep auricular,** a very small branch, passes behind the joint, pierces the anterior wall of the external auditory canal and supplies its lining, including the outer surface of the tympanic membrane. The **anterior tympanic,** often arising in common with the preceding, passes upward and enters the tympanum through the Glaserian fissure (p. 449).

The **small meningeal** (Fig. 195) goes upward to enter the foramen ovale through which it reaches the dura mater of the middle fossa of the skull and the Gasserian ganglion.

The **great** or **middle meningeal** (Fig. 194) passes upward between the two roots of the auriculo-temporal nerve (Fig. 192); its intra-cranial course has been seen (p. 324).

The **inferior dental artery** (a. alveolaris inferior) passes downward with the inferior dental nerve and enters the dental canal of the mandible, which it traverses as far as the mental foramen (Fig. 195); here it **divides** into *incisor branches* for the teeth and the *mental branch*, which latter leaves the canal through the mental foramen and breaks up into branches for the muscles and skin of the chin and lower lip. The *incisor branch* continues forward to supply branches to the incisor teeth. Before entering the dental canal, the artery gives off a *lingual branch*,

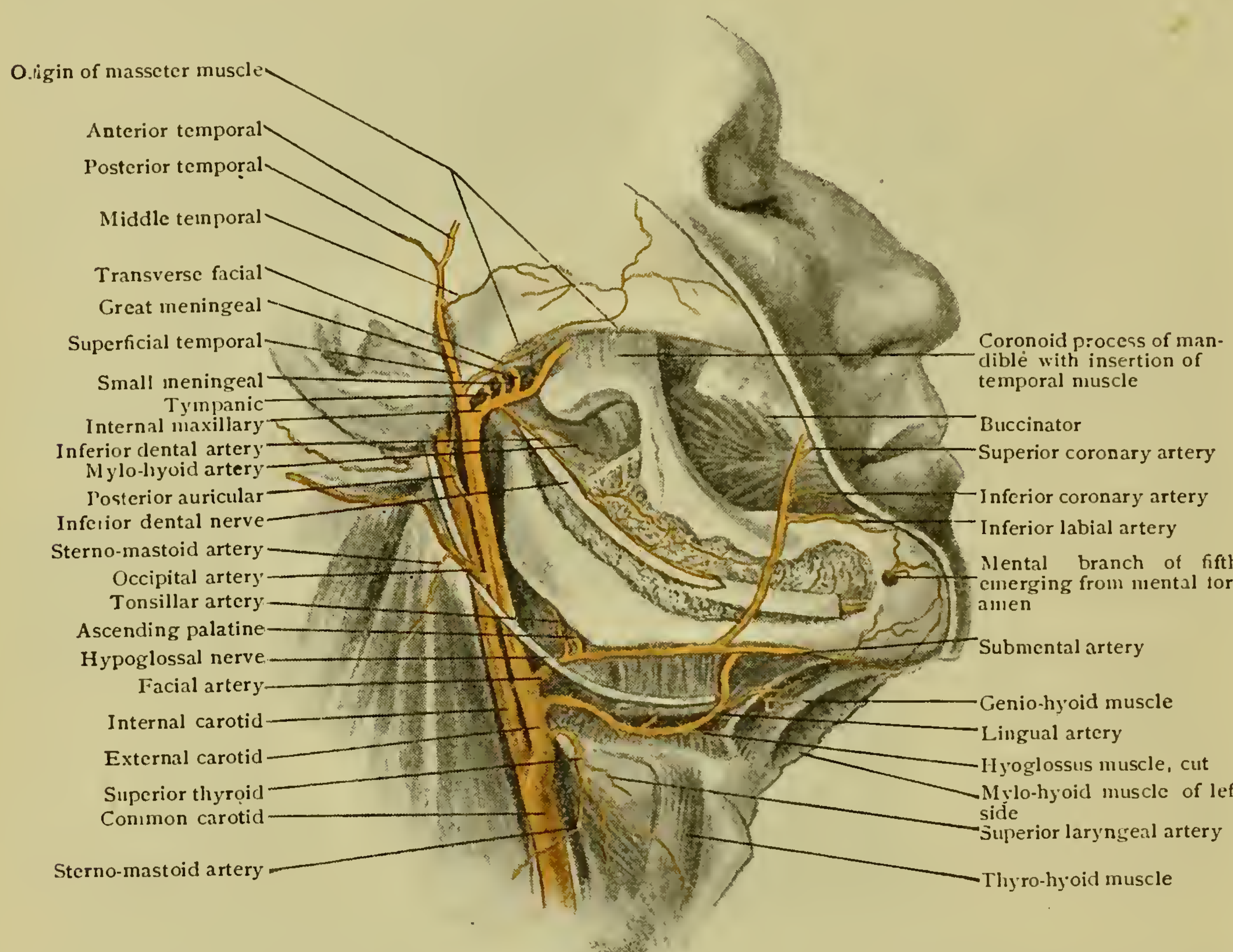

FIG 195.—External carotid, internal maxillary and inferior dental arteries; condyle and outer table of mandible have been removed.

which accompanies the lingual nerve to the tongue, and the *mylo-hyoid branch* (Fig. 195), which accompanies the mylo-hyoid nerve to the under surface of the mylo-hyoid muscle. In its course through the dental or mandibular canal, the artery distributes branches to the molar, premolar and canine teeth.

The **second** or **pterygoid portion** of the internal maxillary artery is that part of the vessel which lies between the internal and external pterygoids or upon the latter muscle. It is **related** with the lingual and inferior dental nerves if beneath the external pterygoid muscle, its inner and outer relations depending also upon its situation with reference to

that muscle, being in relation externally with the ramus of the jaw and the temporal muscle if situated *upon* the external pterygoid.

The **branches** are the *deep temporal*, the *pterygoid*, the *masseteric*, and the *buccal*. The dissection of the **deep temporal branches,** two in number (p. 407), should be completed and their ramifications in the temporal fossa between the temporal muscle and the bone noted, as well as their branches to the muscle and pericranium and their anastomoses with the middle temporal artery.

The **pterygoid branches** usually include two or three small vessels, variable in origin and course, destined for the supply of the pterygoid muscles.

The **masseteric** is a small branch which passes across the sigmoid notch of the mandible to reach the deep surface of the masseter (p. 403).

The **buccal branch** arises near the upper border of the external pterygoid, either on its outer or inner surface, according to the position of the internal maxillary, and passing forward and downward with the buccal nerve reaches the surface of the buccinator muscle and anastomoses with branches of the facial.

The **third** or **spheno-maxillary portion** is that part of the artery contained within the spheno-maxillary fossa. Its dissection must be deferred (p. 418). Having followed each of the vessels mentioned above, the dissection of the nerves of the region is to be completed.

The Mandibular Nerve or **Inferior Maxillary Division of the Trigeminus.**—The **origin** of the *sensory portion* of this nerve from the Gasserian ganglion and the course of the *motor portion* (motor root of the fifth) beneath the ganglion have been seen (p. 336) as well as the exit from the skull of both portions through the foramen ovale. Upon leaving the foramen, the two parts of the nerve unite to form a single trunk, which almost immediately divides into two, an **anterior** and a **posterior division,** each of these two, however, containing both motor and sensory fibres, although in the anterior trunk the motor fibres predominate, while the posterior trunk contains chiefly sensory fibres. The nerve is related by its inner surface with the otic ganglion (Fig. 196), to be examined later (p. 416).

The **branches** of the mandibular nerve before its division are the *recurrent* or *meningeal branch* (n. spinosus), which enters the skull with the middle meningeal artery through the foramen spinosum to be distributed to the dura of the middle fossa and to the mucous membrane of the mastoid cells; and the *internal pterygoid nerve.* The **internal pterygoid nerve** (Fig. 196) furnishes the motor root to the otic ganglion and passing under the posterior border of the internal pterygoid muscle is distributed to its deep surface.

The **branches of the anterior trunk** are the *masseteric, deep temporal, buccal* and *external pterygoid.* These have all been isolated wholly or in

part and the routes by which they reach the muscles indicated by their names have been followed (pp. 407 and 408). It only remains to complete their dissection to their points of origin from the parent trunk and then to identify and clean the parent trunk itself. The **buccal branch,** it may be said here, is a sensory nerve for the skin of the cheek and the mucous membrane of the mouth and is not therefore a nerve of supply for the buccinator muscle, this muscle being innervated by the buccal branch of the facial (p. 394). Thus the anterior division of the mandibular nerve is motor with the exception of the buccal branch.

The **branches of the posterior trunk,** which is the larger of the two divisions, are the *auriculo-temporal*, the *inferior dental* and the *lingual*.

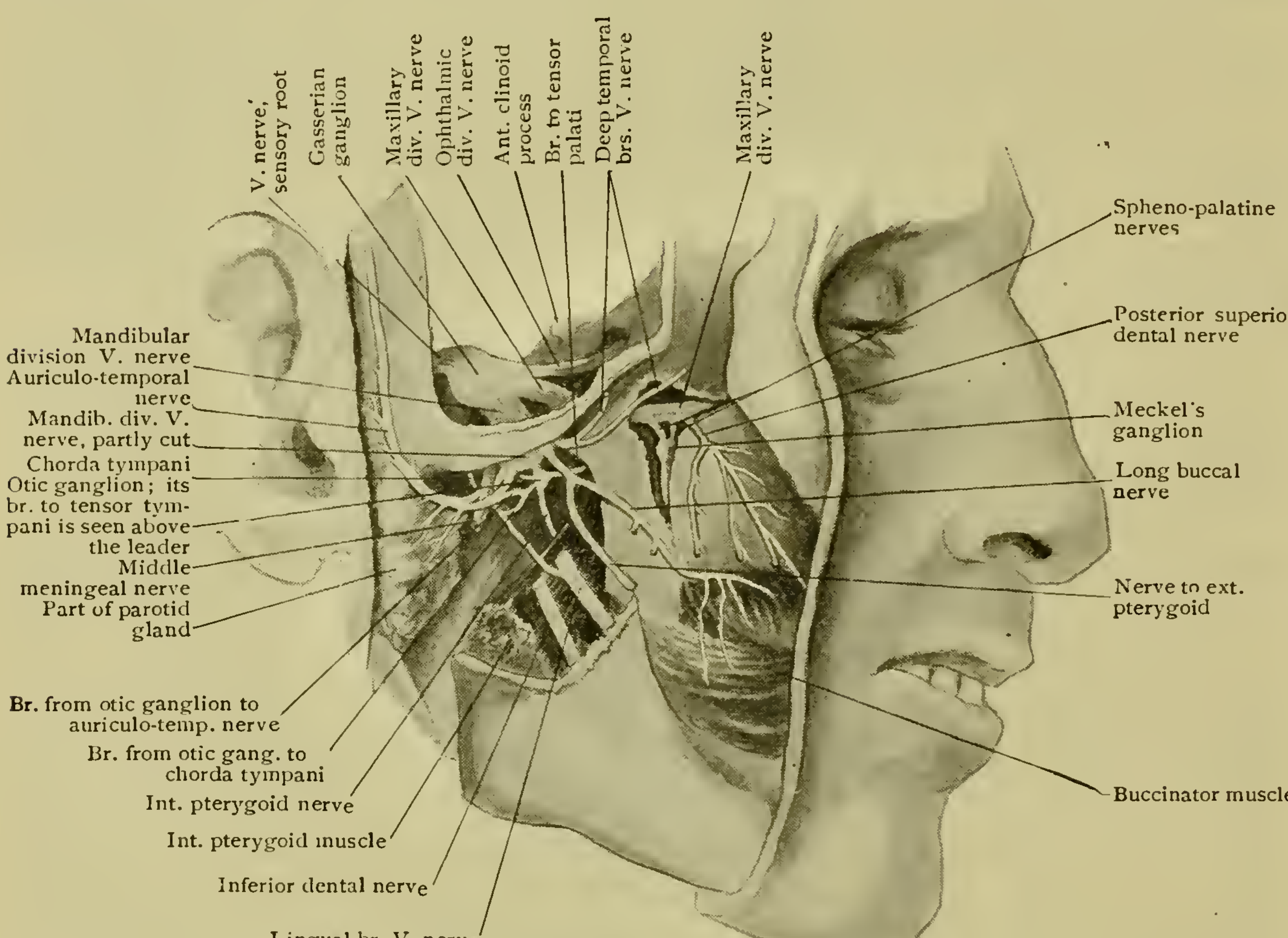

FIG. 196.—Dissection showing lateral view of spheno-palatine and otic ganglia.

The **auriculo-temporal nerve** arises by two roots between which will be found the middle meningeal artery (Fig. 196). Passing backward from beneath the external pterygoid to the neck of the mandible above the first part of the internal maxillary artery, it passes behind the temporo-mandibular joint into the parotid gland and turns upward with the superficial temporal artery; its further **course** and its **branches** have been dealt with (pp. 318 and 402).

The **lingual nerve** (sometimes called the "gustatory nerve") passes forward and downward between the internal and external pterygoid muscles, upon the inner side of the inferior dental nerve, and emerging

from under the external pterygoid passes between the internal pterygoid and the ramus of the jaw and in front of the inferior dental (Fig. 196); passing forward from this point across the outer surfaces of the superior constrictor and the stylo-glossus it reaches the interval between the outer surface of the hyo-glossus and the submaxillary gland (p. 374), passes beneath Wharton's duct and runs along the side of the tongue toward its apex beneath the mucous membrane. Its position with reference to the mouth cavity will be seen later (p. 467). Beneath the internal pterygoid muscle, the lingual nerve is joined by the chorda tympani (p. 455), a branch of the facial nerve but conveying also glosso-pharyngeal fibres for the special sense of taste (p. 455). The lingual is usually connected with the inferior dental nerve by a small strand which may cross the internal maxillary artery. The **branches** go to the mucosa of the front part of the mouth and tongue (p. 465).

The **inferior dental nerve** (n. alveolaris inferior), the largest of the branches of the mandibular, passes downward, at first under the external pterygoid, then between the ramus of the mandible and the internal pterygoid in company with the inferior dental artery, and enters the mandibular or dental canal (Fig. 192), passing forward through which it divides, at the mental foramen, into the *incisor* and *mental branches*.

The **branches** are the *mylo-hyoid*, the *dental*, and the two terminal branches, the *incisor* and *mental*.

The **mylo-hyoid nerve** arises just before the inferior dental nerve enters the dental canal. Passing forward and downward along the groove on the inner surface of the ramus of the mandible and reaching the under surface of the mylo-hyoid muscle, where it passes beneath the submaxillary gland and the facial artery and vein, it supplies the mylo-hyoid and the anterior belly of the digastric.

The **dental branches** (rr. dentales inferiores) arise in the dental canal and supply the molar and premolar teeth (Fig. 192). The **incisor branch** (n. alveolaris inferior anterior) supplies the canine and incisor teeth.

The **mental nerve** has been examined (p. 398).

The course of the inferior dental nerve through the dental canal should be exposed by removing a part of the outer table of the mandible (Fig. 195). This may be effected by sawing with a Hey's saw in a fore-and-aft line approximately parallel with the alveolar border of the jaw and about midway between it and the mental foramen, and making another saw-cut one third of an inch below the first, and cautiously elevating the included segment of bone with an elevator or bone-chisel.

In common with other parts of the trifacial, the inferior dental nerve may be the seat of **intractable neuralgia.** The nerve may be reached through the mouth and *resected* just before it enters the dental canal, the mucous membrane being cut along the anterior margin of the ramus of the mandible—easily felt back of the molar teeth

—the lingula serving as a guide to the foramen and hence to the nerve. An easier but less desirable way of reaching it, is to trephine the outer table of the ramus over the beginning of the canal. If the *mental branch* only is involved, this may be reached at its exit from the mental foramen by an incision through the mucous membrane of the oral vestibule, the lower lip being everted.

The branches of the posterior division of the mandibular nerve are all nerves of common sensation—disregarding for the present the fibres reaching the lingual nerve through the chorda—except the mylo-hyoid, which is a motor nerve. It is to be noted that the mandibular nerve is the motor nerve for the muscles of mastication and the sensory nerve for a part of the dura mater, for parts of the temporal region and of the skin of the cheek, for the skin of the chin and skin and mucous membrane of the lower lip, for the lower teeth, the mucous membrane of the mouth in part and the mucous membrane of the anterior two thirds of the tongue, including the filiform and fungiform papillæ.

The Otic Ganglion.—The Otic or Arnold's ganglion may be exposed by pulling backward the trunk of the mandibular nerve or by cutting part of it away (Fig. 196), since the ganglion lies close to the inner side of the latter beneath the base of the skull. It may also be reached from within the pharynx (Fig. 219).

The **motor root** of the ganglion is derived from the closely related internal pterygoid nerve (Fig. 196). The **sympathetic root** comes from the plexus on the middle meningeal artery. The **sensory root** is received through the small superficial petrosal nerve, which is made up of fibres from the tympanic plexus of the glosso-pharyngeal—and hence from the petrous ganglion of the glosso-pharyngeal of which Jacobson's nerve is a branch—and of fibres from the geniculate ganglion of the facial. The route of the small superficial petrosal has been seen (p. 336). Motor fibres from the facial may also reach the ganglion through the small superficial petrosal nerve; some of the sensory fibres are regarded as taste-fibres and these may go either to the tympanic plexus and by way of the glosso-pharyngeal to the brain, or to the geniculate ganglion, since the latter belongs to the sensory part of the facial nerve, the pars intermedia.

The **branches** of the otic ganglion are *communicating branches* to the auriculo-temporal (secretory fibres for the parotid gland) and to the chorda tympani and lingual nerves; and *branches of distribution* to the tensor tympani (Fig. 196) and tensor palati (Fig. 219).

The Internal Pterygoid Muscle (Fig. 196).—**Origin,** the inner surface of the external pterygoid plate and that part of the tuberosity of the palate bone included between the pterygoid plates, and by a separate slip from the outer surfaces of the tuberosities of the palate bone and superior maxilla; **insertion,** the inner surface of the angle and of the ramus of the mandible below the dental foramen; **action,** to elevate the mandible, and to assist the external pterygoid in producing the for-

ward and lateral movement of the jaw; **nerve=supply,** the internal pterygoid branch of the mandibular nerve.

The downward, outward and somewhat backward direction of this muscle should be noted. Its outer surface is **related** above with the external pterygoid muscle, the dental and lingual nerves, the chorda tympani nerve, a part of the parotid gland and frequently with the internal maxillary artery; below with the ramus of the jaw, the spheno-mandibular ligament, the internal maxillary artery, the inferior dental

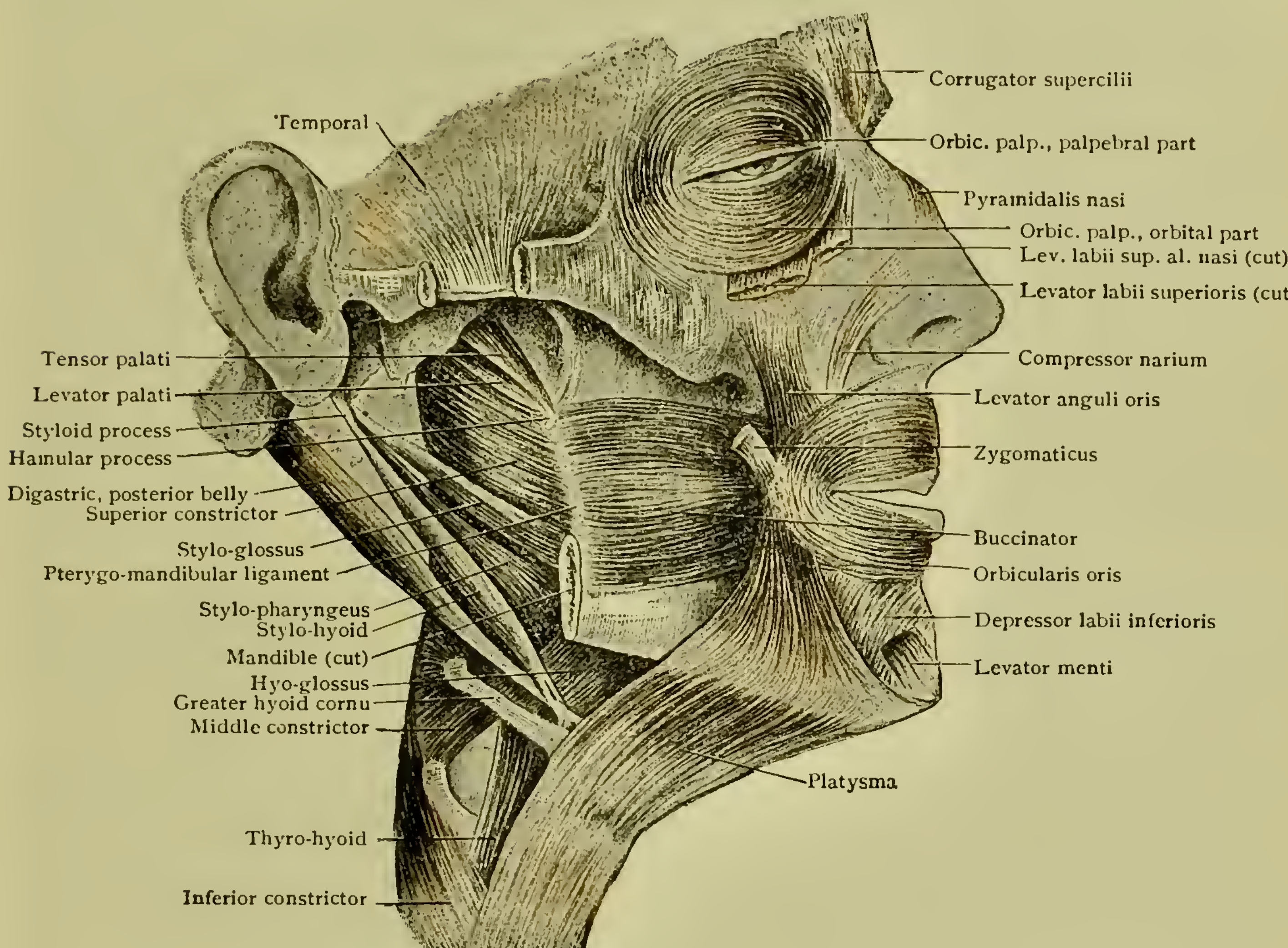

FIG. 197.—Oral, pharyngeal, and styloid groups of muscles; part of mandible has been removed to show deeper structures.

vessels and nerves and the lingual nerve. Its inner surface is in relation with the tensor palati (Fig. 217) and below this is separated from the superior constrictor by a small interval.

The internal pterygoid muscle should not be removed. Its anterior border may be displaced backward, however, to display the pterygo-mandibular ligament and as much of the superior constrictor of the pharynx as may be accessible.

The **pterygo=mandibular** or **pterygo=maxillary ligament** or raphe is a thickened band of the bucco-pharyngeal portion of the cervical fascia which is attached above to the lower extremity of the internal pterygoid plate and below to the posterior end of the mylo-hyoid ridge of the

mandible. Its anterior edge gives attachment to a part of the buccinator; its posterior edge, to part of the superior pharyngeal constrictor, its inner aspect, related with the mouth-cavity, being covered by mucous membrane. Noting the partial origin of the superior constrictor from this band, this line of origin may be traced to the lower extremity of the ligament and to the *mandibular portion* of the muscle's origin, the latter being the inner surface of the mandible below the posterior extremity of the internal oblique line (mylo-hyoid ridge). The part of the constrictor that arises from the lower third of the internal pterygoid plate may be seen by following the ligament upward (Fig. 197).

The **spheno-maxillary fossa** may be examined in part only at this stage of the dissection. If the pterygo-maxillary fissure, through which it communicates with the zygomatic fossa, be rather wide, some idea of the fossa may be obtained; if not, the posterior border of the fissure, i. e., the pterygoid process, may be eaten away with the bone forceps (Fig. 196). The fossa contains the *superior maxillary nerve* on its way to the orbit, *Meckel's ganglion* and the *spheno-maxillary portion of the internal maxillary artery* and the *branches* of these structures.

The **third** or **spheno-maxillary portion of the internal maxillary artery** (p. 413), which begins at the interval between the two heads of the external pterygoid and includes that part contained within the spheno-maxillary fossa, although not completely accessible now, will be considered here. The **branches** are the *alveolar*, the *infraorbital*, the *descending palatine*, the *Vidian*, the *pterygo-palatine* and the *naso-* or *spheno-palatine.*

The **alveolar** (a. alveolaris superior posterior), given off at the pterygo-maxillary fissure, passes downward upon the tuberosity of the maxilla and divides into numerous small branches, some of which enter the posterior dental canals to supply the upper molar and premolar teeth and the lining of the maxillary antrum, while others pass forward to the gums, communicating with branches of the buccal artery.

The **posterior dental nerves** (rami alveolares superiores posteriores), arising from the superior maxillary nerve in the spheno-maxillary fossa as a single trunk or as two, will be found in company with the alveolar artery, and are to be dissected with that vessel; they likewise enter the posterior dental canals and supply the upper molars and the lining of the antrum, after having given *superior gingival branches* to the gums.

The other branches of the spheno-maxillary portion of the internal maxillary will be traced at later stages of the work (pp. 431 and 476).

The **relations of the malar and superior maxillary bones** to each other, of the malar to the temporal and zygomatic fossæ, of the superior maxilla to the zygomatic and spheno-maxillary fossæ, and of both bones to the orbit are worthy of note.

The **malar bone,** by reason of its exposed position as one of the most projecting bones of the face, is exposed to direct violence. Being of firm texture and intimately related with the superior maxilla, and articulated also with the great wing of the sphenoid, the frontal and the squamosa of the temporal, it is far less apt, however, to be *broken* as the result of a blow than to be driven into the maxilla, with the result of much damage to that bone. On account of its connections and relations as noted above, a severe blow upon the malar bone may cause concussion of the brain or the extravasation of blood within the orbit.

The **superior maxilla,** by reason of the hollowing out of its body to form the antrum of Highmore or maxillary antrum and the resulting weakness of its walls, as well as because of its carrying the upper teeth and because of its relation to the mandible and to the malar bone, may be very easily *broken.* Thus a blow on the malar bone, on the under aspect of the chin, or on the top of the head when the chin is fixed, may produce serious comminution of this bone.

The superior maxilla shares with the mandible a rather considerable liability to implication during the course of or following infectious diseases, such as typhoid fever, and also a susceptibility to the fumes of phosphorus, periostitis followed by necrosis occurring.

Diseases of the antrum will be referred to later (p. 471); at present it will be sufficient, in connection with such disease, to note the relation of the body of the maxilla to the nasal chamber on the inner side, the oral cavity below, the zygomatic fossa externally and behind, the spheno-maxillary fossa behind and the orbit above.

Excision of the superior maxilla, which may be required for such disease, involves not only the cutting through extremely vascular soft tissues but the separation of the bone from the bones with which it articulates as pointed out above.

The **relations of the mandible** should be noted as to (a) its connection with the base of the skull through its articulation with the glenoid fossa; (b) the relation of its ramus to the pterygo-maxillary region and (c) of its body to the mouth-cavity, giving origin as it does to the mylo-hyoid muscle, which forms a large part of the floor of that cavity, and to the buccinator, one of the chief structures of the cheek.

The **mandible** may be *broken* in any part by direct violence, but the most usual seat of fracture is near the mental foramen where the bone is weakest. Fractures are not uncommon despite the fact that certain anatomical features tend to protect the bone, such as the *situation of the ramus* between two thick muscles, the internal pterygoid and the masseter, the *horse-shoe shape* of the bone which confers a certain degree of elasticity, and its *mobility.* From its intimate relation to the mucous membrane of the mouth, the latter is usually torn, making these fractures *compound.* The degree of *displacement* varies, the anterior fragment being drawn downward by those factors which depress the uninjured jaw (p. 406), the mylo-hyoid tending to restrict displacement in fracture of the body of the bone, since it is attached to both fragments.

The **inferior dental nerve** is not so often injured in these fractures as one might expect, but even though it escape at the time of injury it is quite apt to be injuriously compressed by the callus at a later date, the pressure causing *neuralgia* or *paralysis* according to its degree.

The liability of the inferior maxilla to *inflammation* (osteitis) during or after typhoid fever and kindred diseases and its susceptibility to the action of phosphorus fumes upon the part of those employed in match factories is a well established clinical fact.

The Nerve-Supply of The Face.—The **motor** nerve-supply of the *facial muscles* or *muscles of expression*, including the *buccinator*, the *occipito-frontalis* and the *small auricular muscles*, is the facial or seventh cranial nerve; the motor supply to the *muscles of mastication* is the mandibular division of the trigeminus.

The **sensory** supply is from the trigeminus mainly, assisted by the auricularis magnus through its branches to the parotid region; the distribution of the **mandibular division** through the *mental portion* of its inferior dental branch (p. 398), its *buccal branch* (p. 414) and its *auriculo-temporal branch* (p. 402) has been indicated; the distribution of the **superior maxillary division** through its *infraorbital branch*, which divides into *palpebral*, *nasal* and *labial* portions (p. 397), and its *temporo-malar branch* for the temporal region and the malar portion of the cheek, have also been traced (pp. 319 and 397); the distribution of the **ophthalmic or first division** through the *supraorbital* and *supratrochlear* branches for the skin of the forehead, the *infratrochlear* and the *external branch of the nasal nerve* for the skin of the nose, has been followed (pp. 318 and 319).

Having completed the dissection of the pterygo-maxillary region, the dissector should turn his attention once more to the submaxillary region of the neck for the purpose of examining more fully some of the deeper structures of this region, such as the internal carotid artery, the mylo-hyoid, lingual, glosso-pharyngeal and pneumogastric nerves, the ascending pharyngeal artery and the stylo-pharyngeus muscle. Easier access to these structures may be secured by sawing the mandible within a quarter of an inch of the symphysis, with care to avoid lacerating the mucous membrane of the mouth. This allows the body of the jaw to be tilted upward, and as the upper part of the ramus has already been removed, freer access is secured to the deeper part of the neck. Let the dissector now turn to pages 373, 379 and 380 and follow the deeper structures one after another as there directed.

The skull-cap should now be again removed preparatory to the dissection of the contents of the orbital cavity.

THE DISSECTION OF THE CONTENTS OF THE ORBIT.

To expose the contents of the orbital cavity it will be necessary to break through the roof of the orbit in the anterior fossa of the skull. Several light blows applied with a chisel and hammer over the middle of the roof of the orbit will fracture the bone and the opening may be enlarged by the use of bone-forceps back to a point one quarter of an inch in front of the optic foramen, and forward almost to the vertical part of the frontal bone, care being exercised not to go farther internally or externally than the inner and outer walls of the orbit. Instead of using

the hammer and chisel, a trephine or small convex saw may be employed to make the requisite opening. Having gotten through the bone, the fragments should be carefully removed, leaving the periosteum. The periosteum should be noted as being continuous in front with the pericranium on the outer surface of the cranial bones and behind through the sphenoidal fissure and the optic foramen with the dura mater. The periosteum may then be incised from the apex of the orbit forward

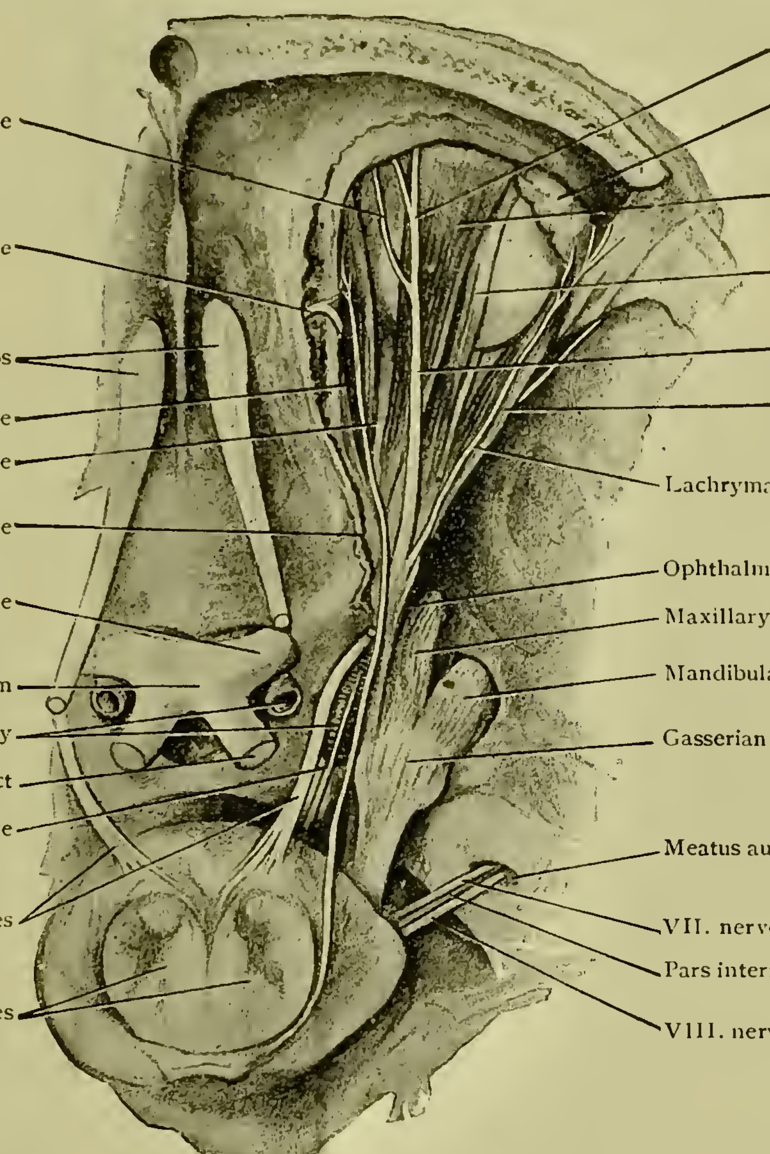

FIG. 198.—Roof of right orbit has been removed to expose branches of ophthalmic division of trigeminal nerve; Gasserian ganglion, and third, fourth, sixth, seventh and eighth nerves also seen.

and may be reflected toward either side. The first things to come into view will be the frontal nerve and the supraorbital artery.

The **frontal nerve,** the largest of the three branches of the ophthalmic division of the fifth, entering the orbit through the sphenoidal fissure (p. 336), passes directly forward with the **supraorbital artery** between the levator palpebræ superioris and the periosteum, and divides into the *supraorbital* and *supratrochlear* nerves, whose points of emergence from the orbital cavity to reach the forehead have been already noted (p. 318). The former nerve and the artery (Fig. 200) should be followed to the supraorbital foramen.

The **pathetic** or **fourth nerve** (n. trochlearis) (Fig. 198), the smallest of the cranial nerves, enters the orbit through the inner and highest part of the sphenoidal fissure and crosses the origin of the levator palpebræ superioris. To expose it the opening in the roof of the orbit may be extended backward, the portion of the lesser wing of the sphenoid above the sphenoidal fissure being removed but the optic foramen not being encroached upon. Picked up here, the nerve should be followed in its course forward and inward toward the inner wall of the orbit until it enters the upper surface of the superior oblique muscle near its outer border.

Since the superior oblique muscle assists in rotating the eyeball downward and outward, paralysis or section of the trochlear nerve will produce an inward and upward squint.

Having followed these nerves the surface of the elevator of the upper eyelid should be cleaned from its origin (page 392) to its insertion. This muscle may be divided near the front part of the orbit and reflected backward, the nerves above mentioned being pulled to one side, and its own nerve from the motor oculi being found as it enters the deep surface of the muscle. This exposes the superior rectus muscle.

The Superior Rectus (Fig. 198).—**Origin,** the upper margin of the optic foramen and the sheath of the optic nerve; **insertion,** the sclerotic tunic of the eyeball several lines back of the corneal margin; **action,** to rotate the eyeball upward and somewhat inward, owing to its oblique direction from the apex of the orbit, the obliquity of its pull being corrected by the inferior oblique muscle; **nerve-supply,** the upper division of the oculo-motor nerve, the nerve of supply entering the deep surface of the muscle.

The **lachrymal nerve,** the smallest of the three terminal branches of the ophthalmic division of the fifth, should be sought at the back part of the orbit as it passes through the sphenoidal fissure and should be traced in its course toward the outer wall of the orbit above the external rectus muscle to its entrance into the lachrymal gland (Fig. 198). After distributing *branches* to the lachrymal gland, it pierces the superior palpebral ligament and passes on to *terminate* in the upper eyelid, where it gives branches to the skin. Just before its entrance into the lachrymal gland it gives off a small branch which passes downward to communicate with the temporo-malar nerve. The **lachrymal artery,** one of the largest branches of the ophthalmic, given off from that vessel before it enters the orbit, should be traced forward and outward to the lachrymal gland. Its terminal *branches*, the **external palpebral,** pass to the upper and lower eyelids, anastomosing with the internal palpebral; some small branches pass to the temporal fossa through the malar foramina.

The superior rectus may now be divided near its origin and turned forward, when its nerve will be seen entering its deep surface.

The **superior division of the third nerve** will now be seen as it comes into the orbit through the sphenoidal fissure above the nasal nerve and between the two heads of the external rectus muscle. Its branches,

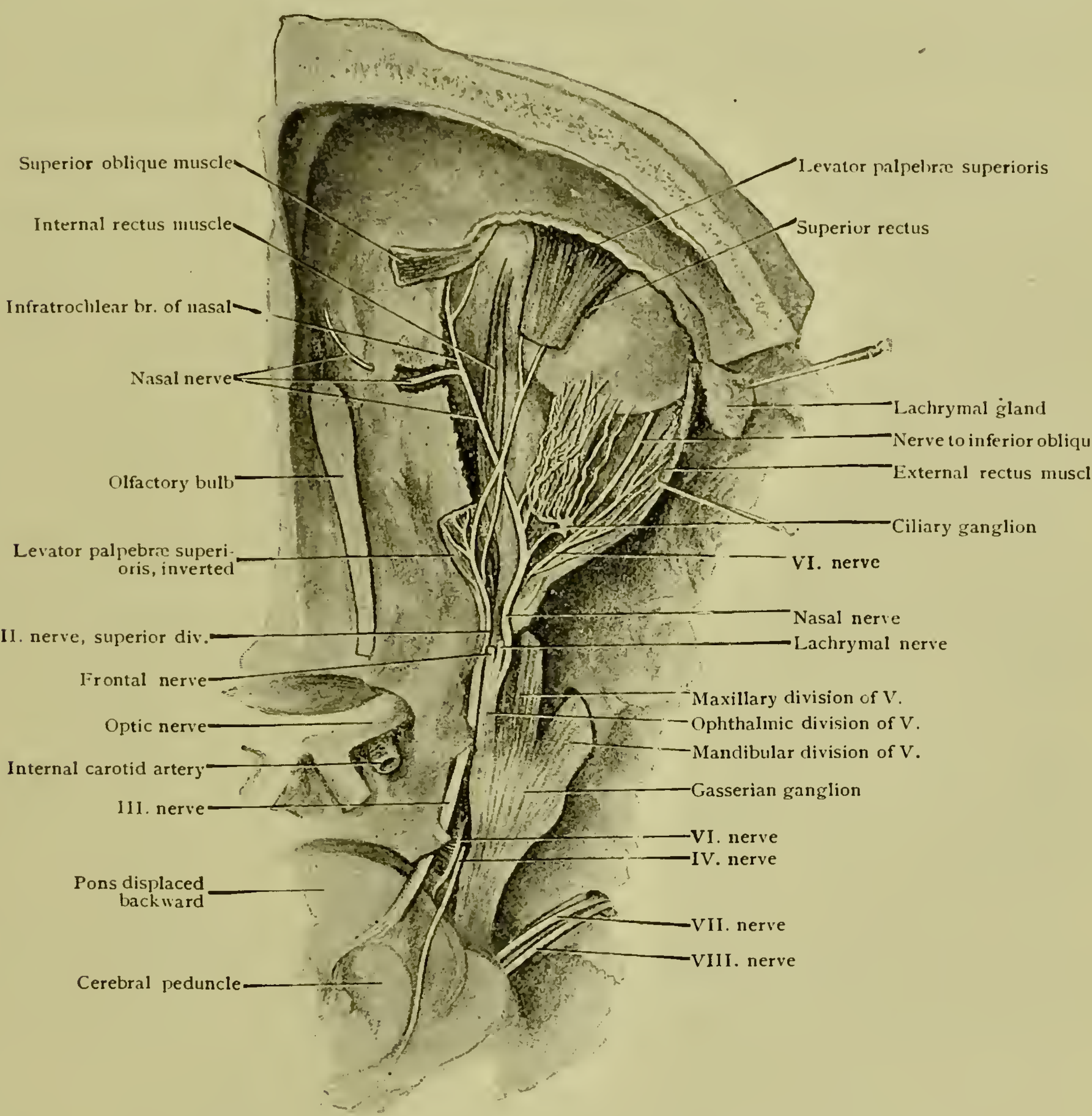

Fig. 199.—Deeper dissection of right orbit, viewed from above; branches of nasal nerve shown.

given off as it passes upward and inward over the optic nerve, are the *two branches*, already found, which supply the levator palpebræ superioris and the superior rectus.

The **nasal nerve** (n. nasociliaris), the third branch of the ophthalmic division of the fifth, passes into the orbit through the sphenoidal fissure below the superior division of the third nerve and between the two heads of the external rectus. It should be sought at this point and

traced forward along the outer side of the optic nerve, and then obliquely inward across the optic nerve—in which part of its course it is accompanied by the ophthalmic artery—toward the inner wall of the orbit to the position of the anterior ethmoidal foramen, which it enters to regain the cranial cavity (Fig. 199). Emerging from the cranial end of the anterior ethmoidal foramen, it passes forward upon the cribriform plate of the ethmoid to reach the nasal slit beside the crista galli, through which aperture it again quits the cranial cavity to reach the cavity of the nose (Fig. 219), ultimately appearing—its external branch—upon the side of the nose (p. 394).

The **branches** of the nasal nerve are the *ganglionic* (radix longa) to the ciliary ganglion, which should be dissected and followed to that ganglion; the *long ciliary branches*, which are given off just as the nasal nerve is crossing the optic nerve, should be traced forward to the eyeball; and the *infratrochlear*. The **infratrochlear nerve,** arising as the nasal nerve is entering the anterior ethmoidal foramen, should be traced forward as far as possible; its termination is upon the skin of the face near the inner canthus of the eye after having supplied the lachrymal caruncle and neighboring parts (p. 391).

The External Rectus Muscle (Fig. 199).—**Origin,** by two heads, one from the outer margin of the sphenoidal fissure, and one from the ligament of Zinn (annulus tendineus communis); **insertion,** the outer side of the eyeball; **nerve-supply,** the sixth cranial nerve or abducens; **action,** to rotate outward or abduct the eyeball. This muscle should now be dissected, the external surface being first denuded. Better access to the muscle will be gained as well as to adjacent structures by breaking down the outer wall of the orbit. Pulling the muscle outward, the sixth nerve and its branches will be found upon the inner surface of the muscle.

The **sixth cranial nerve,** the **abducens**, entering the orbit through the outer part of the sphenoidal fissure below the other nerves and above the ophthalmic vein, and passing along the inner surface of the external rectus to terminate in that muscle, should now be isolated (Fig. 201).

Paralysis or section of the sixth nerve will produce inward squint.

The **inferior division of the third nerve,** entering the sphenoidal fissure below the nasal nerve and above the sixth, passes forward and divides into three **branches,** one of which, appearing as if the continuation of the inferior division, gives off a short, rather thick *ganglionic branch* to the ciliary ganglion, which constitutes the motor root of that ganglion, and continues forward along the outer side of the orbit in relation with the inner surface of the external rectus muscle to reach the *inferior oblique muscle*, which it supplies. Another branch passes to the *inferior rectus muscle*, entering its upper surface. A third

branch goes beneath the optic nerve to the *internal rectus*, entering its outer surface; it may be more conveniently traced at a later stage.

Thus, since the superior branch of the third nerve supplies the superior rectus and the levator palpebræ superioris, and the inferior branch, the internal rectus, the inferior rectus and the inferior oblique, this nerve supplies all of the ocular muscles except the external rectus and the superior oblique Through the branches which it gives to the ciliary ganglion and which pass forward with the ciliary nerves to enter the eyeball, it supplies the circular fibres of the iris and the ciliary muscle. Hence, it is related in an important degree to the function of accommodation and to the movements of the eyeball.

The **ophthalmic, lenticular,** or **ciliary ganglion** should be sought in the fatty tissue of the back part of the orbit, upon the outer side of the optic nerve (Fig. 199). It is a small structure, several lines in diameter, connected by its upper posterior angle with the *ganglionic branch of the nasal nerve* which forms its **sensory root,** by its lower posterior angle with the *ganglionic branch* of the inferior division of the *third nerve*, its **motor root;** it receives its **sympathetic root** in the form of filaments from the cavernous plexus of the sympathetic, which come forward through the sphenoidal fissure. Its **branches,** given off from its anterior aspect, are the *short ciliary nerves*, which pass forward in relation with the optic nerve to enter the eyeball by piercing the sclerotic coat in a line encircling the point of entrance of the optic nerve. Passing forward through the eyeball in the grooves on the deep surface of the sclera (p. 553), they supply the ciliary muscle, the iris and the cornea (Fig. 262).

The **short** and **long ciliary arteries,** branches of the ophthalmic artery, are intermingled with the ciliary nerves and must be dissected at the same time as the nerves. They will be found to enter the eyeball by piercing the sclerotic coat near the optic nerve entrance in company with the ciliary nerves.

The Ophthalmic Artery.—The ophthalmic artery **arises** from the internal carotid just as the latter vessel leaves the cavernous sinus. The dissector should follow it forward through the optic foramen, which it traverses in company with and beneath the optic nerve (Fig. 200) to reach the orbit. From its position on the outer side of the optic nerve in the back part of the orbit, it is to be followed inward across the nerve—or occasionally under it—in company with the nasal nerve and the superior ophthalmic vein, toward the inner wall of the orbit, and then forward below the superior oblique and above the internal rectus to terminate by dividing into the palpebral, frontal and nasal branches (Fig. 200). A variation of this arrangement may present in the form of the origin of the vessel from the middle meningeal artery.

The **branches** are the *arteria centralis retinæ*, *posterior ciliary*, *lachrymal*, *muscular*, *supraorbital*, *posterior ethmoidal*, *anterior ethmoidal*, *palpebral*, *nasal* and *frontal*.

The **arteria centralis retinæ** arising near the apex of the orbit enters the optic nerve on its outer and under aspect a short distance from the eyeball (Fig. 200) and passes forward within the nerve to reach the retina (p. 557). The ciliary vessels must be displaced to expose it.

The **posterior ciliary arteries** include the *long* and the *short ciliary*, which arise just over the optic nerve either as a number of small vessels or as two larger trunks. The *short ciliary arteries*, after breaking up into

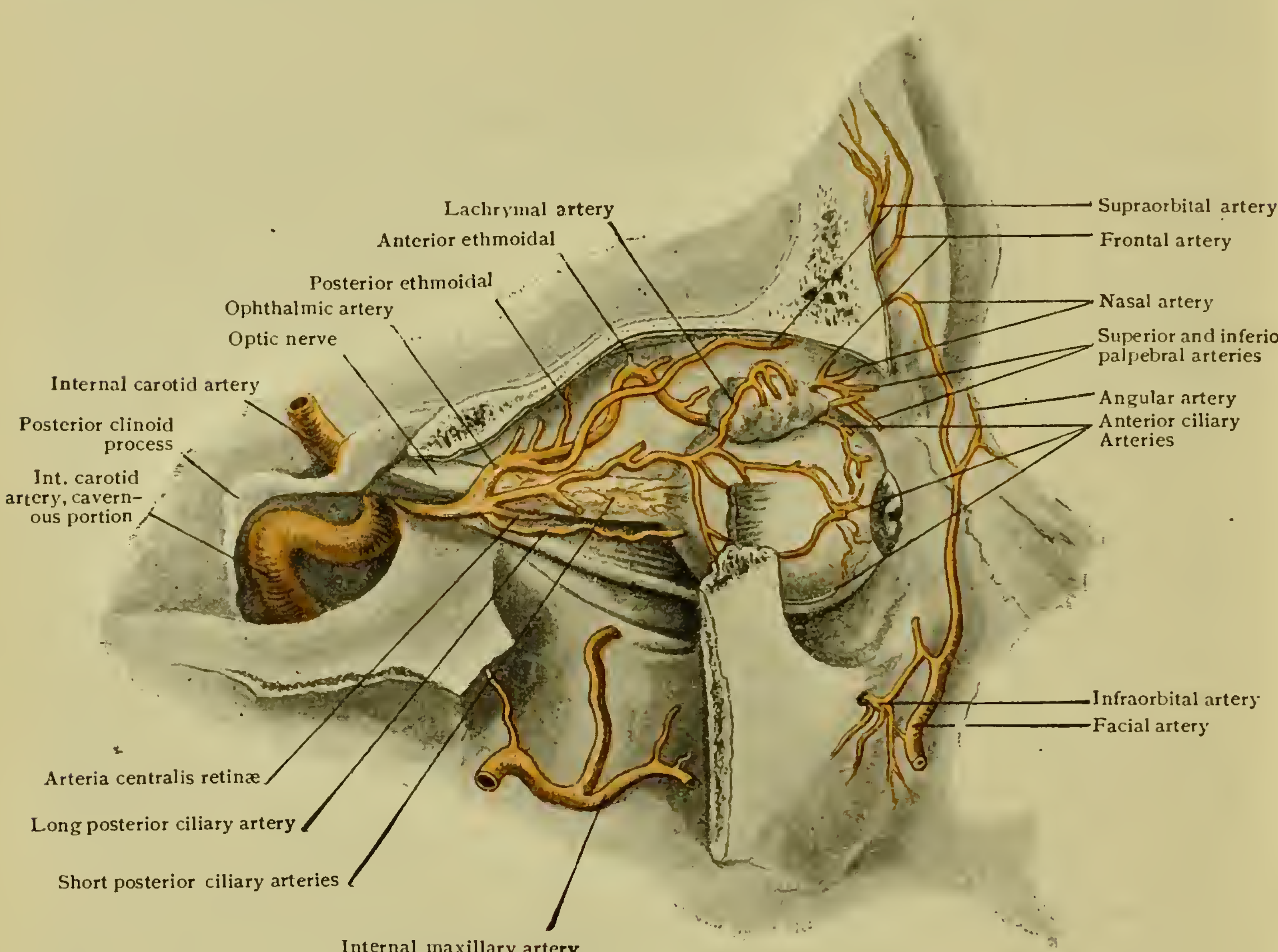

FIG. 200.—Branches of ophthalmic artery, seen from side after removal of lateral orbital wall.

smaller vessels, pierce the sclerotic close to the optic nerve's entrance into the eyeball; the two *long ciliary branches* pass forward, one on each side of the nerve, and enter the eyeball a little farther from the entrance of the nerve. These vessels have already been dissected; their distribution within the eyeball will be considered with the dissection of that organ (p. 556).

The **lachrymal branch** has been found and disposed of in connection with the dissection of the lachrymal nerve (p. 422).

The **muscular branches,** variable in number, size and point of origin, are often represented by an *inferior branch*, which arises on the outer

side of the optic nerve and which supplies the inferior oblique and the inferior, internal and external recti, and a *superior branch*, less constant, arising after the ophthalmic has crossed the optic nerve and going to the superior rectus, the superior oblique and the levator palpebræ; sometimes both branches arise by a common trunk.

The **anterior ciliary arteries,** given off from some of the muscular branches, are four in number and by division and anastomosis with each other form an arterial circle around the periphery of the iris, as will be seen in the dissection of the eyeball.

The **supraorbital artery,** arising from the ophthalmic as that artery crosses the optic nerve, was dissected in connection with the frontal nerve (p. 421); its course after leaving the orbit was seen in dissecting the face and scalp (p. 319).

The **anterior** and **posterior ethmoidal arteries** enter the foramina of corresponding name to reach the cranial cavity and supply the dura mater of the anterior fossa. The **posterior ethmoidal** sends *branches* also to the posterior ethmoidal cells and the upper back part of the nasal septum. The **anterior ethmoidal,** the larger, enters the nasal cavity through the nasal slit; it sends *branches* to the middle and anterior ethmoidal cells and the frontal sinus.

The **palpebral** or **internal palpebral branches** have been encountered in the dissection of the eyelids (p. 391).

The **frontal artery** is a small branch which leaves the orbit at its inner angle and which has been seen on the forehead (p. 319).

The **nasal branch,** sometimes regarded as the continuation of the ophthalmic, escapes at the inner canthus, and has been seen on the face (p. 399).

The Superior Ophthalmic Vein.—The superior ophthalmic vein (Fig. 168) **originates** at the inner front part of the orbit as the **naso-frontal vein,** the latter resulting from two veins coming respectively from the supraorbital and the angular veins (p. 399). Passing through the orbit in rather close relation with the ophthalmic artery (p. 425) it escapes through the lower angle of the sphenoidal fissure to **terminate** in the cavernous sinus, of which it is the largest tributary. It is usually joined at the back of the orbit by the inferior ophthalmic vein (p. 429). Its **tributaries** for the most part correspond to the branches of the ophthalmic artery (q.v.). Through the supraorbital vein, which receives the anterior diploic vein at the supraorbital foramen, it communicates with the venous circulation of the scalp. Through the angular vein, the tributary at the inner canthus of the eye, it communicates with the facial vein. These veins should be worked out as well as their condition will permit.

The communication of the ophthalmic vein with the veins of the scalp and of the face as indicated elsewhere (page 335) has an important clinical application, since infections of the face and scalp may be communicated to the intra-cranial circulation by these channels.

The Internal Rectus Muscle.—**Origin,** the lower and inner margins of the optic foramen by the *ligament of Zinn,* common to this muscle and the inferior rectus; **insertion,** the sclerotic coat of the eyeball near the corneal margin; **action,** to rotate the eyeball inward; **nerve-supply,** the oculo motor nerve (Fig. 199).

In dissecting this muscle, note its relative width; note also the relation of its tendon to the capsule of Tenon (p. 430), a relation that should not be disturbed at present.

The Inferior Rectus Muscle.—**Origin,** the lower and inner margins of the optic foramen in common with the preceding muscle; **insertion,**

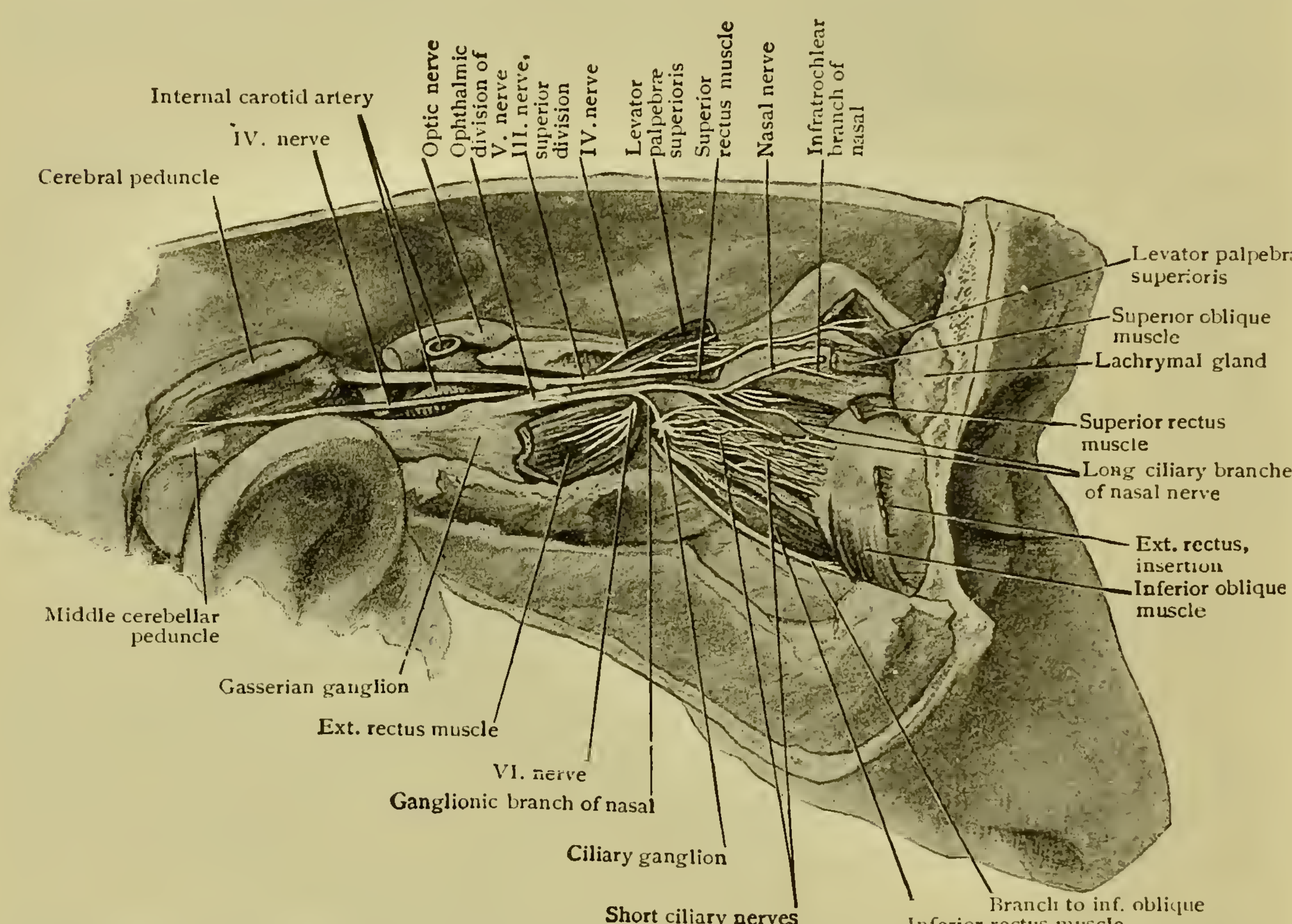

Fig. 201.—Dissection of right orbit after removal of its lateral wall; external and superior eye-muscles have been cut and displaced to expose ciliary ganglion and nerves.

the under aspect of the eyeball; **nerve-supply,** the third nerve; **action,** to rotate the eyeball downward, the obliquity of its pull being corrected by the superior oblique. Access to this muscle may be gained by elevating the optic nerve and the ciliary vessels and nerves and drawing outward the external rectus muscle. Observe the same precaution as to its tendon as in the case of the preceding muscle.

The Inferior Oblique Muscle. — **Origin,** the inner anterior portion of the floor of the orbit (orbital plate of superior maxilla); **insertion,** the outer aspect of the eyeball between the insertions of the external and superior recti; **nerve-supply,** the third nerve; **action,**

to correct the oblique action of the superior rectus in rotating the eyeball upward.

To expose this muscle, the external rectus must be pulled outward and the inferior rectus upward, since it lies beneath the latter and, near its insertion, is between the external rectus and the eyeball (Fig. 201). It is most easily dissected from the front of the orbit.

The **optic nerve,** the second cranial nerve, should now be isolated and traced from the optic chiasm or the point of decussation of the right and left optic nerves (p. 328), to its entrance into the eyeball, after which it may be in part, at least, removed in order to facilitate access to the floor of the orbit.

In tracing the nerve from the cranial cavity, remove, with the bone-forceps, the anterior or upper boundary of the optic foramen. The optic nerve *sheaths* are prolongations of the cerebral membranes and are traceable to the point of entrance of the nerve into the eyeball where they blend with the sclera and the capsule of Tenon.

The Inferior Ophthalmic Vein.—The inferior ophthalmic vein (Fig. 168) **originates** in a venous network on the inner part of the floor of the orbit and often does not exist as a single trunk but consists of a plexus. Its **tributaries** are veins from the structures on the floor of the orbit as well as the *inferior vorticose veins* of the eyeball. The optic nerve and the inferior rectus muscle are to be displaced to gain access to it. It **terminates** either in the cavernous sinus—having passed through the sphenoidal fissure—in the superior ophthalmic vein, or in the pterygoid plexus after passing through the spheno-maxillary fissure.

THE LACHRYMAL GLAND.—The lachrymal gland is found at the upper outer part of the orbit. The portion of the gland seen in this dissection is the **orbital portion,** which rests in contact with the lachrymal fossa of the frontal bone and is held in position by bands of connective tissue passing from the upper and outer surface of its capsule to the orbital periosteum; its concave inner surface is in relation with the levator palpebræ and the external rectus, which separate it from the eyeball. Displacing the gland slightly, the supporting bands which connect it with the periosteum may be demonstrated. The lachrymal nerve and artery have already been traced to the gland. The **palpebral** or **accessory portion** of the gland is in front of the orbital part and projects into the upper eyelid and against the superior palpebral conjunctiva at the fornix. Its form is apparent upon everting the upper lid. It is separated from the orbital portion by the expansion of the tendon of the levator palpebræ superioris. It is to be dissected from in front.

The **ducts** of the lachrymal gland, about twelve to fifteen, open into the outer third of the upper conjunctival cul-de-sac, the ducts from the orbital portion passing through the accessory gland.

The **blood-** and **nerve-supply** have been sufficiently indicated.

Inflammation of the lachrymal gland may terminate in *abscess* of the gland, the pus tending to point through the skin of the upper lid. Retention cysts sometimes occur in the gland.

The Capsule of Tenon (fascia bulbi).—The capsule of Tenon is a rather loose sheath which invests the posterior five sixths of the eyeball, extending therefore to the corneal margin and coming into intimate relation with the ocular conjunctiva, which covers the anterior one-third of the globe of the eye and therefore overlaps the capsule. The capsule of Tenon is so loosely associated with the surface of the sclera by loose-meshed tissue that there is between the two a series of spaces, lined with endothelial cells, which constitute collectively the *episcleral lymph-space* or *Tenon's space* (spatium interfasciale). Where the optic nerve pierces it behind, it becomes continuous with its sheath. The relation of Tenon's capsule to the eyeball is quite analogous to the relation of the cavity of a ball-and-socket joint to the head of the articulating bone.

An attempt should be made to demonstrate the capsule by injecting it with water by means of a hypodermic syringe, making an oblique puncture and avoiding the sclera. This failing, an incision and the introduction of a probe or director will demonstrate the cavity.

The ocular muscles already dissected should be traced to their insertions into the sclera, when it will be seen that they pierce the capsule of Tenon opposite the equator of the globe, the capsule being prolonged upon the tendons and blending with the muscular sheaths, except in the case of the superior oblique, the prolongation upon whose tendon extends only to the pulley. A curved probe passed forward through an incision in the capsule while the latter is held tense with forceps grasping the edge of the incision, will aid in demonstrating the relations of the tendons to the capsule.

From the sheath of the superior rectus there is an extension to the tendon of the elevator of the upper lid; from the sheath of the inferior rectus, one to the attached border of the tarsal plate of the lower eyelid; from the sheath of the external rectus, a strong band, the *external check ligament*, passes outward to be attached to the orbital surface of the malar bone; from the sheath of the internal rectus, a similar but less strong band, the *internal check ligament*, passes to the crest of the lachrymal bone. The check ligaments limit the action of the internal and external recti and therefore the extent of inward and outward rotation of the eyeball.

The **suspensory ligament** (Lockwood) is a thickening of the inferior part of the capsule of Tenon extending to the inner and outer walls of the orbit in close association with the check ligaments. It supports the eyeball, any interference with it, as by removal of its external attachment in excision of the superior maxilla, allowing the eyeball to descend.

The relation of the ocular tendons to Tenon's capsule has an important bearing upon tenotomy or section of these tendons for strabismus, i.e., when a tendon is cut, its action upon the eyeball is not lost, its connection with the capsule preventing its complete retraction.

Any remaining fat and connective tissue should now be removed from the orbit that its floor may be examined.

The **fat of the orbit** favors the spread of pus in *orbital abscess*, the inflammation being excited by foreign bodies or other forms of traumatism or extending to the orbit from neighboring regions. The orbit may be invaded by tumors of adjacent parts, especially those of the antrum.

The **infraorbital artery** should be sought at its entrance into the orbit through the spheno-maxillary fissure and traced forward along the floor of the orbit to its entrance into the infraorbital canal. Having traversed this canal in company with the infraorbital nerve, it emerges upon the face at the infraorbital foramen where it has already been encountered (p. 395).

The **branches** of the infraorbital artery are the *anterior dental* branches (aa. alveolares anteriores superiores), which descend through the anterior dental canals in the wall of the antrum to supply the mucous membrane of that cavity and the incisor teeth. These vessels will be found in tracing the infraorbital nerve (see below). Small *branches* are also given off to the structures of the orbit; the branches pierce the roof of the infraorbital canal.

The **superior maxillary nerve** is also found on the floor of the orbit in company with the infraorbital artery.

The **dissection of the eyeball** is to be made at a later stage of the work (p. 551).

The structures at the back of the orbit should now be cleared away, the entire lesser wing of the sphenoid should be removed and that part of the greater wing which forms the outer boundary of the sphenoidal fissure should be eaten away with the bone forceps, with care to avoid trespassing upon the foramen rotundum. This procedure will expose the **spheno-maxillary fossa,** which was exposed on its lateral aspect in dissecting the pterygo-maxillary region (p. 418).

The superior maxillary nerve may now be followed throughout its course as indicated below.

The Superior Maxillary Nerve (n. maxillaris).—The second or maxillary division of the trigeminus or fifth nerve arises from the Gasserian ganglion, being a purely sensory nerve, and escapes from the cranial cavity into the spheno-maxillary fossa (p. 336). From this fossa it enters the orbital cavity through the spheno-maxillary fissure and passing forward with the infraorbital artery enters the infraorbital canal under the name of the **infraorbital nerve;** leaving the canal through the

infraorbital foramen, it divides into its terminal branches, the palpebral, nasal and labial.

The **branches** of the superior maxillary nerve are, in the skull, the *dural branch* (p. 336); in the spheno-maxillary fossa, the *orbital* or *temporo-malar*, *spheno-palatine* and *posterior superior dental;* in the infraorbital canal, the *middle superior dental* and *anterior superior dental;* on the face, the (inferior) *palpebral*, (external) *nasal* and (superior) *labial* (p. 397).

The **orbital** or **temporo-malar branch** (n. zygomaticus) enters the orbit through the spheno-maxillary fissure and divides into the *temporal* and the *malar*. The **temporal branch** (r. zygomaticotemporalis) should be traced along the outer wall of the orbit, as it follows a groove in the malar bone, to the foramen in that bone, through which it enters the temporal fossa; it communicates in the orbit with the lachrymal nerve; its further course has been seen (p. 319). The **malar branch** (r. zygomatico-facialis) passing along the lower outer part of the orbit escapes through a canal in the malar bone and reaches the facial surface of that bone (p. 397).

The **two spheno-palatine branches** (Fig. 196) pass downward to join the spheno-palatine (Meckel's) ganglion, of which they constitute the sensory root.

The **posterior superior dental branches** (rr. alveolares posteriores superiores) have been dissected (p. 418).

The infraorbital canal must now be opened to expose the infraorbital nerve and artery. The thin posterior part of its roof may be divided with scissors; the more massive anterior portion will require the chisel and hammer, or a small saw. The remaining parts of the infraorbital nerve and artery and the branches they give off in the canal are now to be examined.

The **middle superior dental branch** of the infraorbital nerve (r. alveolaris superior medius) runs downward and forward through a canal in the outer wall of the antrum (Fig. 192) and supplies the bicuspid teeth. Its communication with the posterior superior dental marked by the so-called *ganglion of Valentin* is to be noted, as is also its communication with the anterior superior dental marked also by an enlargement, the so-called *ganglion of Bochdalek*.

The large **anterior superior dental branch** (r. alveolaris superior anterior) may be traced from its origin near the front of the canal downward through a canal in the anterior wall of the antrum. It supplies the incisor and canine teeth and sends a *nasal branch* (Fig. 192) through a small canal to the mucous membrane of the front part of the inferior meatus of the nose.

The Spheno-Palatine or Meckel's Ganglion (spheno-maxillary or nasal ganglion).—This, the largest of the cranial sympathetic ganglia, bears the same relation to the maxillary nerve as do the ciliary and the

otic ganglia respectively to the first and third divisions of the trigeminus. It is situated in the spheno-maxillary fossa below the maxillary nerve. It was partially exposed in a previous dissection (p. 418). While it is not possible to trace all the branches now, it seems convenient to consider it at this stage.

The **roots** of the ganglion, or its **branches of communication,** are, as in the case of the other ganglia of the fifth nerve, a *motor*, a *sensory* and a *sympathetic root.*

The **sensory root** is derived from the superior maxillary nerve through its spheno-palatine branches. Most of the fibres of these nerves are dendrites of the Gasserian ganglion cells. Although apparently the sensory root of the ganglion, the fibres for the most part merely pass through or by it on their way to the branches of the ganglion. Some of the fibres are axones of the cells of the ganglion.

The **motor root** comes from the facial nerve through the large superficial petrosal nerve and by way of the Vidian nerve.

The **sympathetic root** is derived from the carotid plexus of the sympathetic and therefore ultimately from the superior cervical ganglion through the great deep petrosal nerve (Fig. 219). The origin of the *great superficial petrosal* (geniculate ganglion of the facial) and its course through the hiatus Fallopii and across the middle cranial fossa to the cartilage occupying the foramen lacerum medium have been pointed out (p. 336). The *great superficial* and *great deep petrosals* unite within this cartilage to form the *Vidian nerve*, which passes forward through the Vidian canal (Fig. 219) to the spheno-maxillary fossa, where it joins Meckel's ganglion. Let the dissector note in the dry skull the posterior aperture of the Vidian canal on the anterior wall of the middle lacerated foramen and its anterior orifice at the root of the pterygoid process, i.e., on the posterior wall of the spheno-maxillary fossa.

The **branches of Meckel's ganglion** are: the **ascending,** or *orbital branches;* the **descending branches,** or the *large*, *small* and *accessory posterior palatine nerves;* the **internal branches,** or the *posterior superior nasal* and *naso-palatine nerves;* and the **posterior branch,** or the *pharyngeal* or *pterygo-palatine nerve.*

The **orbital branches,** several small filaments, pass into the orbit through the spheno-maxillary fissure and help to supply its periosteum, sending some twigs to the sphenoidal and posterior ethmoidal cells either through the posterior ethmoidal foramen or a special aperture between the os planum and the frontal bone.

Beyond tracing the internal branches to the spheno-palatine foramen and the descending branches to the lower part of the fossa (the beginning of the posterior palatine canal) (Fig. 196), nothing is to be done with these branches until they are met with in the dissection of the naso-pharynx. In connection with the branches of the spheno-palatine gan-

glion it is well to note the general relations of the spheno-maxillary fossa and the situations of the foramina and canals that open upon its walls, since the nerve-branches leave the fossa through these apertures and in a general way correspond with the latter in name.

The **maxillary** or superior maxillary nerve, like the first and third divisions of the trifacial nerve, may be the subject of intractable neuralgia. As a radical operation for this condition, the nerve is *resected* at the infraorbital foramen; or the nerve may be followed back through the infraorbital canal—the orbital structures being displaced to expose the floor of the orbit and the canal being opened—and divided either in the orbit or the spheno-maxillary fossa; or it may be divided still further back at the foramen rotundum, in which case the **spheno-palatine ganglion** is sometimes *removed* with the nerve and sometimes is left.

The nerve may also be approached through the pterygo-maxillary region after the removal of a part of the zygomatic arch (Ross's operation).

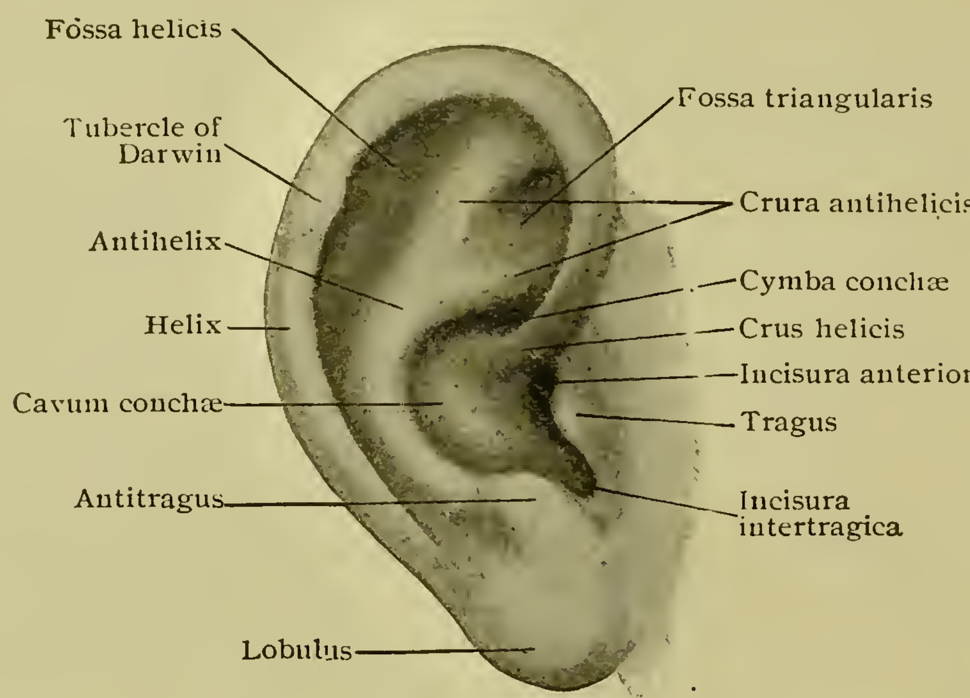

FIG. 202.—Right auricle, outer aspect.

THE EAR

The auditory apparatus includes the *external ear*, the *middle ear* and the *internal ear*, contained within which last named part is the essential nervous mechanism or peripheral end-organ to which all the other parts are subsidiary.

THE EXTERNAL EAR

The external ear is adapted by its form to the collection of sound-waves and to their conveyance to the outer wall of the middle ear. It consists of the external expanded part, the *auricle*, and a passage, the *external auditory canal.*

THE AURICLE OR PINNA.—The auricle should be noted as presenting a deep depression, the **concha,** surrounding the orifice or meatus of the external auditory canal; a soft dependent **lobule** below; a prominent

rim, the **helix,** beginning at the lobule and ending as the *crus helicis* in the bottom of the concha, and the **tragus,** which partly hides the meatus. Below and behind the tragus and separated from it by the **incisura intertragica** is the **antitragus,** curving upward and backward from which is a ridge, the **antihelix,** which bifurcates above to enclose the **fossa triangularis.** The gutter between the helix and the antihelix is the **fossa helicis** or scaphoid fossa. The **concha** is divided by the crus helicis into the upper *cymba* and the lower *cavum conchæ* or concha proper.

The pinna has been to a considerable degree dissected in following the **blood=vessels** and **nerves** upon its surfaces (pp. 317 and 402). On its inner (posterior) surface are found the auricular branch of the occipital artery and branches of the posterior auricular artery, with the auricular branch of the auricularis magnus and occipitalis minor nerves

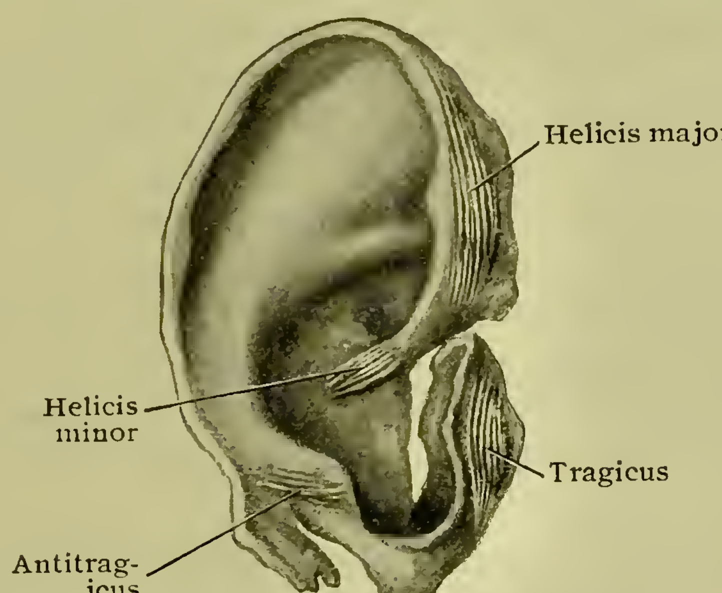

FIG. 203.—Cartilaginous framework of right auricle, with intrinsic auricular muscles; outer surface.

and the auricular branch of the vagus (Arnold's nerve). On the external (anterior) surface are branches of the posterior auricular artery and the anterior auricular branches of the temporal arteries, with the anterior auricular branches of the auriculo-temporal nerve and filaments from the auricularis magnus nerve.

The **extrinsic muscles of the auricle** have also been dealt with (pp. 317 and 318). The further dissection of the pinna is to be effected by carefully removing the thin and closely adherent skin, preserving the small **intrinsic muscles** if possible, and noting the cartilaginous basis of the pinna. The *superficial fascia* is scant and contains little or no fat.

The Auricular Cartilage.—The cartilage of the pinna which is highly elastic, upon being denuded is seen to belong to all parts of the structure except the lobule and to be prolonged inward, as an incomplete tube, to form the cartilaginous portion of the external auditory canal. A cleft or incision, the **incisura terminalis auris,** cuts in between the upper

part of the tragus and the crus of the helix and, extending downward, separates the posterior margin of the meatus from the concha and almost divides the cartilage into two distinct parts. These two partially separated portions are therefore continuous at the lower part of the auricle but are separated elsewhere. The smaller portion of the cartilage not only forms the cartilaginous segment of the external auditory canal but the tragus as well; it presents two small clefts, the **fissures of Santorini.**

If the upper part of the auricle be pulled outward, a fibrous band, one of the **intrinsic ligaments,** may be demonstrated connecting the upper part of the tragus to the crus of the helix, thereby completing the front boundary of the meatus. Other such *bands* pass between different parts of the main cartilage.

If the top of the pinna be pulled strongly upward and backward, one of the **extrinsic ligaments,** the *anterior ligament,* is demonstrated passing from the **spine** (spina helicis) at the anterior part of the helix and from the tragus to the root of the zygoma; this may be felt in the living subject if the same manipulation be resorted to. Pulling the auricle strongly forward, the other extrinsic ligament, the *posterior ligament,* will be revealed as a stronger band passing from the cranial side of the concha to the mastoid process beneath the posterior auricular muscle. An effort to dislodge the tubular portion of the auricular cartilage from the temporal bone will demonstrate the firmness of its attachment to the latter at the rough margin of the bony external meatus. The **cauda helicis** will be seen as the downward projecting process or lower extremity of the helix.

The **intrinsic muscles** of the auricle, which are rudimentary in man, are small portions of muscular tissue attached to the cartilage and the skin.

The **helicis minor** lies upon the crus helicis and passes on to the anterior part of the helix.

The **helicis major** arises from the spine of the helix and passes upward to be inserted into the skin over the anterior part of the helix.

The **tragicus** is upon the outer surface of the tragus, its fibres directed vertically.

The **antitragicus** starts on the outer surface of the antitragus and passes upward and backward to the cauda helicis.

The **transversus,** the best developed of the series, is on the cranial aspect of the auricle bridging over the depression here which corresponds to the antihelix.

The **obliquus,** also on the cranial aspect of the auricle, passes over the depression corresponding to the lower limb of bifurcation of the antihelix.

Supernumerary auricles are occasionally met with in the vicinity of the ear, either on the cheek or the side of the neck; they probably result from aberrant growth of one or more of the six small tubercles around the dorsal extremity of the hyo-

mandibular cleft from which the auricle develops. Another effect of defective union of these tubercles is the occurrence of abnormal fissures in the auricle (vide infra).

The popular association of the *size and form* of the auricle with certain mental and moral characteristics would seem to be as well founded as the association of the peculiarities of facial physiognomy with such characteristics. It is interesting to note in this connection, the free blood- and nerve-supply of the auricle, its variation in size and form in different animals, and the significance usually attached by clinicians to non-traumatic *othæmatomata* or *blood-tumors of the auricle* as being prodromal signs of insanity. Of interest also is the *ear-point* or *tubercle of Darwin* at the anterior margin of the upper part of the vertical portion of the helix; this tubercle, rather conspicuous in the six months' fetus, represents the pointed extremity of the ear of certain animals.

The Meatus Auditorius Externus (meatus acusticus).—The external auditory canal or meatus—the meaning of *meatus*, literally a going, a passage-way, seems often to be mistaken by the student to mean *aperture*—begins at the concha and passes in a general direction inward and somewhat downward and forward. This may be verified by passing a blunt instrument carefully into the canal until its progress is arrested by the **tympanic membrane,** which closes the inner end of the canal and separates it from the middle ear cavity. Its length is then seen to be one and one-quarter inches as measured from the tragus and one inch as measured from the bottom of the concha. Comparing the length of the meatal portion of the auricular cartilage with that of the canal in the dry bone, it will be seen that the **cartilaginous portion** of the canal includes a little more than one third of its entire length, a proportion that varies at different ages; thus, at the fifth or sixth year, the bony and cartilaginous portions are of about equal length; at one year of age, the bony canal is one third the entire length, and at birth, the canal is entirely cartilaginous, since the pars tympanica at this time is merely a ring, incomplete above.

It will be noted also that the outer, cartilaginous part of the canal inclines upward and that, at its union with the bony canal, there is a prominence or upward curvature of the floor, from which point the canal inclines downward, as well as forward. Hence, to get a view of the tympanic membrane (p. 441), the canal is straightened by pulling the auricle upward and backward. Passing a probe into the canal, note that its anterior wall is longer than its posterior wall—the measurements being respectively one and three-eighths inches and one inch—since the tympanic membrane is placed in an oblique plane.

The external auditory canal is lined with **skin** which presents some special features and which is closely attached to the cartilage and the periosteum, being thinner in the floor of the bony canal and especially thin over the tympanic membrane. **Sebaceous glands** and **hairs** occur in the skin of the cartilaginous part; **ceruminous glands** are found here also as well as in the roof of the bony canal. The latter, modified sweat glands, secrete the **cerumen** or **ear=wax.**

The **blood-supply** of the canal is derived from the vessels that supply the auricle (q. v.) and also from the internal maxillary through its deep auricular branch (p. 411). The **veins** practically follow the same vessels. The **lymphatics** pass to the parotid nodes, the mastoid nodes and to the nodes along the external jugular vein. The **nerves** are the meatal branches of the auriculo-temporal (p. 402) and Arnold's nerve (p. 435). The vessels and nerves gain ingress and egress to and from the canal partly through the fissures of the auricular cartilage (p. 436).

The external auditory canal is often the seat of **furuncles** or **boils**, infection occurring through the sebaceous glands or through abrasions produced by foreign bodies or by scratching or too vigorous attempts at cleaning the meatus. More diffuse inflammation may be excited by **impacted cerumen**, which also produces dulness of hearing and sometimes marked vertigo.

The relation of the canal to the neighboring parts is important. The relation of the *posterior wall* to the sigmoid portion of the lateral sinus has been indicated (p. 333); this wall is also related to the mastoid cells, the bony partition between them being perforated by small blood-vessels which may serve as avenues for the conveyance of infection in either direction. The *upper wall* is separated from the cranial cavity by bone, which may be eroded by inflammation, allowing the latter to extend into the cranium. The relation of the *anterior wall* to the temporo-mandibular joint and its possible fracture by blows on the chin have been indicated (p. 419), as also its relation to the parotid gland and the possibility of the extension of inflammation or pus from the gland to the canal or the reverse. The *fissures in the cartilage* (p. 436) constitute the avenues of communication.

THE MIDDLE EAR

The middle ear includes the *tympanic cavity*, the *mastoid antrum* and *mastoid cells* and the *Eustachian tube*. This series of cavities is lined with mucous membrane which is directly continuous with that of the naso-pharynx, a fact directly related with the genetic or developmental relations of the parts, since the middle ear may be looked upon as a partially separated portion of the pharynx. The first inner visceral furrow, which is an antero-posterior groove on the inner surface of the lateral wall of the head-end of the gut-tract, forms, by the fusion of its edges, the cavity of the middle ear, including the Eustachian tube. At the ventral end of the furrow, however, such fusion does not occur; this part of the furrow therefore continues to be a part of the lateral wall of the pharynx and the Eustachian tube thus becomes an avenue of communication between the tympanum and the pharynx. The first outer visceral furrow or hyo-mandibular cleft, a groove on the external surface of the embryo corresponding with the first inner furrow and separated from it by the thin closing membrane, becomes obliterated by the fusion of its edges except at its dorsal extremity. This enclosed end of the outer furrow develops into the external auditory canal, its margins growing up in the form of little tubercles to produce the pinna. The dorsal end of the closing membrane becomes

the tympanic membrane. Defective closure of the hyo-mandibular cleft results in some form of *branchial fistula.*

THE TYMPANUM.—The tympanum or tympanic cavity is a small space, narrowest from side to side, in the petrosa of the temporal bone. Its transverse diameter is 2 to 4 mm., its antero-posterior diameter is 12 mm. and its vertical, 15 mm.

Note the depressed area on the upper aspect of the petrosa just within the lateral cranial wall; this portion of the petrosa is a thin plate of bone, the **tegmen tympani,** and forms the roof of the tympanum and a part of the roof of the mastoid antrum. Note the

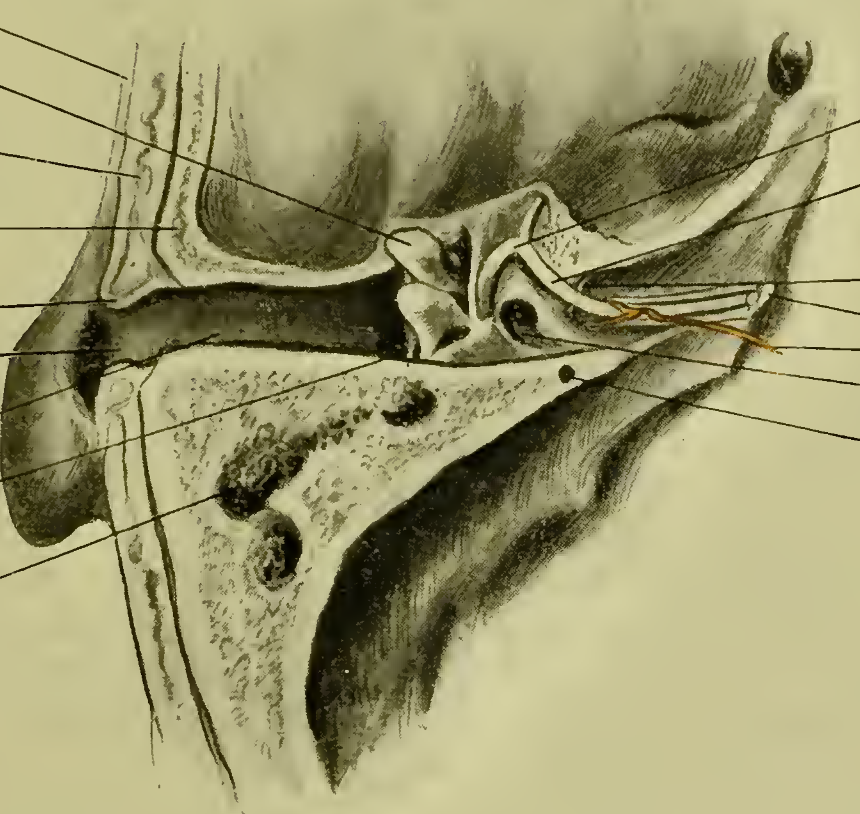

FIG. 204.—Horizontal section of left temporal bone exposing various parts of the ear.

petro=squamous suture crossing the tegmen in the antero-posterior direction. Note the *elevation* on the inner side of the depressed tegmen which corresponds to the **superior semicircular canal,** a part of the internal ear.

Now apply the saw in a horizontal plane, beginning on the outer surface of the skull, in a line parallel with the upper border of the zygoma and three fourths of an inch above it, altering the direction of the saw slightly if necessary that it may include and remove the tegmen tympani. It should pass through the elevation of the superior semicircular canal and if possible remove the roof of the internal auditory canal. The structures within the latter are to be safeguarded by passing a director into the canal above the nerves and artery. If the section does not

remove the roof of the internal canal, the latter may be removed by two parallel cuts with a small saw corresponding with the course of the canal. This section exposes the external auditory canal, the tympanic cavity, the mastoid antrum, a part of the internal ear, and the internal auditory canal (Fig. 204). The upper margin of the tympanic membrane, the upper part of the malleus and the Fallopian or facial canal—its horizontal part which runs along the upper part of the inner wall of the tympanum —are also brought to view.

That part of the tympanum above the level of the highest part of the tympanic membrane is the **epitympanic recess** or **attic** or **aditus ad antrum** (*aditus*, an approach), since it presents the opening, behind, of the mastoid antrum. The part of the tympanum below the attic is the **atrium.** Note that the head of the **malleus** or hammer, one of the middle ear ossicles, is an occupant of the attic (Fig. 206) and that a second ossicle, the **incus** (anvil), which articulates by its body with the head of the malleus, is also for the most part in the attic. The short process of the incus rests in a little fossa on the rear wall of the attic, the **fossa incudis** (fossa of the incus).

The dissector should now withdraw his attention from the tympanic cavity long enough to examine the mastoid cells.

THE MASTOID CELLS.—The largest of the cells of the mastoidea is the **antrum** (Fig. 204), which, as seen above, communicates by a rather large aperture with the epitympanic recess of the tympanum. Many other cells are present, some of which, those in the lower part of the process, the **diploetic cells,** contain bone-marrow; the others, which are lined with mucous membrane prolonged from the tympanum and the mastoid antrum and which contain air, are distinguished as the **pneumatic** or **air-cells.** It should not be forgotten that they are accessory portions of the middle ear cavity.

As the cells, including the antrum, are somewhat variable in position and size, the section just made may not have sufficiently exposed them; in that case, the bone may be chipped away to the necessary extent. The cells extend into the squamosa over the external auditory canal, and may extend to the sigmoid fossa, into the root of the zygoma, into the occipital bone, to the apex of the petrosa or to the floor of the Eustachian tube.

The mastoid process is absent at birth, but the antrum is present; the process appears in the second year and gains its pneumatic cells at about the time of puberty.

Note the **relations of the mastoid antrum** to the fossa sigmoidea and hence to the lateral sinus; to the cranial cavity, from which it is separated by the thin tegmen, the latter presenting the petro-squamous suture; to the external auditory canal; to the tympanic cavity; and to the surface.

The periosteal covering of the mastoid process may be the seat of inflammation leading to **subperiosteal abscess** over the mastoid. More common is the suppurative inflammation of the pneumatic cells, or **mastoid disease.** This is caused chiefly by middle ear disease (otitis media) by direct extension, but may originate in inflammation of the integumentary and periosteal lining of the external canal (p. 438).

The gravity of mastoid disease depends upon the anatomical relationships as indicated above. Thus, from the relation of the antrum to the sigmoid fossa, and the connection of the venous circulation of the mastoid cells with the lateral sinus through the mastoid vein, septic thrombosis of the lateral sinus may occur (p. 333); it is the most common intra-cranial complication of mastoid disease. From the relation of the antrum to the cranial cavity, septic meningitis, or thrombosis of the superior petrosal sinus may occur, the inflammation extending to these structures either through the petro-squamous suture of the tegmen, or the latter itself being eroded.

To reach the mastoid antrum, its **relation to the surface** must be taken into account. The supra-meatal spine is usually recognizable, when the denuded bone can be touched, just behind the upper part of the external meatus. The *supra-meatal triangle of Macewan* is bounded above by the supra-mastoid crest, in front by the posterior margin of the meatus and below by an imaginary line joining the lower part of the meatus with the posterior part of the crest. It is through this area that the bone is trephined to reach the mastoid antrum.

Returning now to the consideration of the tympanum, let the dissector examine its several walls in succession.

Outer Wall of the Tympanum.—The **outer wall** (paries membranacea) is constituted, for the **atrium,** by the tympanic membrane or drum-head, and the rim of bone to which it is attached; for the **attic,** by the scutum, a portion of the temporal bone which separates the attic from some of the mastoid cells.

The Tympanic Membrane.—The tympanic membrane consists of a *middle fibrous*, an *outer cuticular* and an *inner mucous membrane layer*, the last being a part of the mucous lining of the cavity. The manubrium (handle) of the malleus extends from above downward to a point below the centre of the membrane between its fibrous and mucous layers. The **fibrous layer** is attached to a groove, the **sulcus tympanicus,** in the inner extremity of the tympanic bone, which forms a cylinder incomplete above, the gap thus left at the inner end of the external canal being the **notch of Rivinus.** The fibrous layer being absent at the notch of Rivinus, and the other two layers being lax, this upper portion of the membrane is called the **membrana flaccida** or **Shrapnell's membrane.** The anterior and posterior terminations of the incomplete bony ring are called respectively the **anterior** and **posterior spines** and from them pass two folds to the short process of the malleus, the **anterior** and **posterior tympano-malleolar folds.**

The **external surface of the tympanic membrane** should now be examined, a part of the front wall of the external canal being chipped away to afford a better view. It is seen to be placed in an oblique plane, the antero-inferior portion being farthest from the outer orifice of the external canal. Its longest diameter, 9.5 to 10 mm., is directed down-

ward and forward; its shortest diameter is 8.5 to 9 mm. The outer surface is concave, the most depressed point being called the **umbo** or **navel.** As seen in life, the membrane presents a characteristic pearly gray tint, the handle of the malleus being evident as an opaque streak extending upward and forward from the umbo. In front of the upper end of the handle of the malleus, its **short process** is apparent. Above and in front of this is **Shrapnell's membrane** bounded by two streaks, the **anterior** and **posterior tympano-malleolar folds,** which diverge from the short process of the malleus. At some little distance behind the upper half of the manubrium, the long process of the incus is indicated by a nearly vertical streak. The **"cone of light,"** of sector shape, is

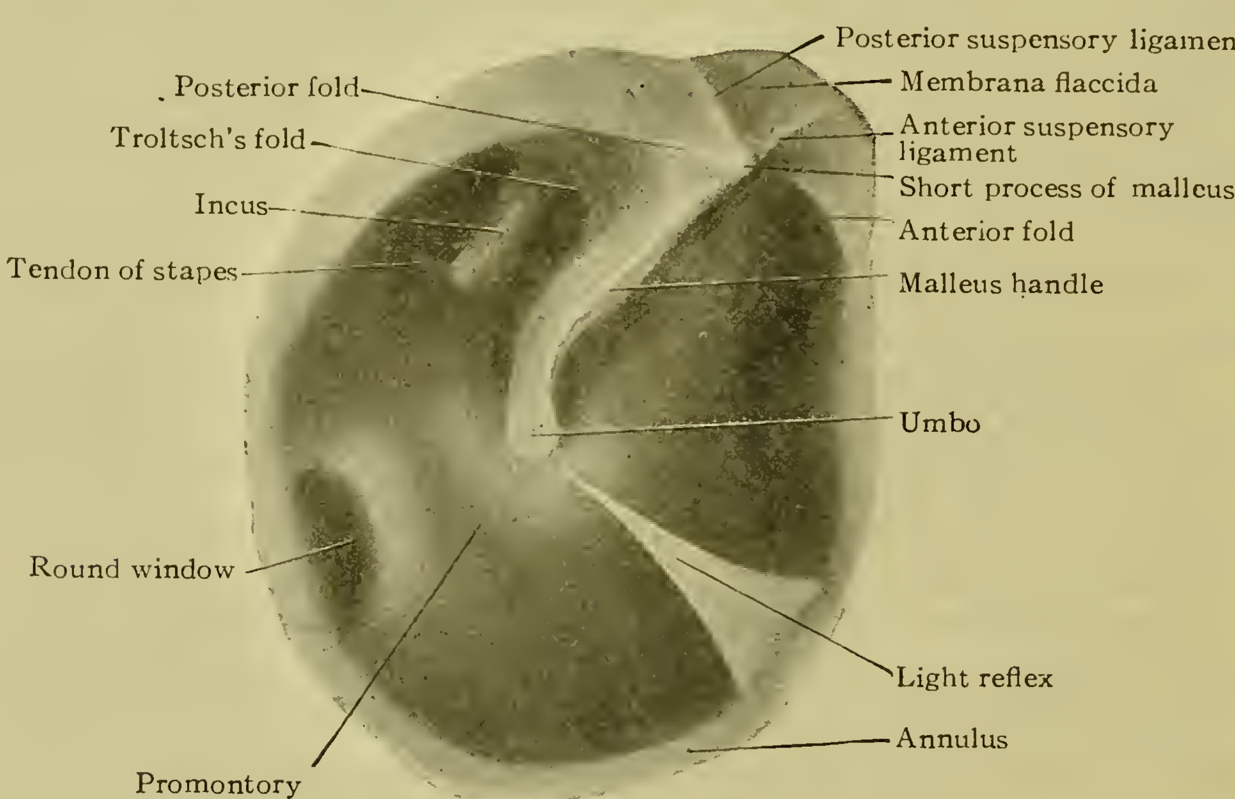

FIG. 205.—Normal drum-head of right side as seen with mirror. × 6.

seen in the anterior lower quadrant with its apex at the umbo; it is due to the manner in which the concave surface reflects the light and is quite characteristic of a normal membrane.

Inflammation of the tympanic membrane is **myringitis.** The membrane bulges outward when there is pus or other fluid in the tympanum. **Paracentesis** of the membrane or its incision to evacuate pus is done in the lower posterior quadrant. Examine the cavity of the tympanum and note that the cavity is *narrowest* (2 mm.) at the level of the umbo, and that an incision through the supra-umbilical region of the membrane would injure the ossicles and might also wound the inner wall of the tympanum.

The **inner surface** of the tympanic membrane (Fig. 206) can only be examined satisfactorily after making a section of the bone in a sagittal plane, just to the inner side of the membrane. This should be done with a fine saw, to avoid undue mutilation of the soft parts and the

bone. Furthermore, before making this section, the ossicles should be examined, the chorda tympani nerve identified if possible and the apertures on the anterior wall of the cavity noted.

The **auditory ossicles,** the *malleus*, *incus* and *stapes*, form a chain by which the tympanic membrane or drumhead is connected with the internal ear. The malleus is attached to the membrane, while the stapes is fitted to the oval window on the inner wall of the tympanic cavity, the incus connecting the malleus and stapes, since it articulates with both.

The **malleus** (hammer) (Fig. 207), as seen above, has a large *head*, which is lodged in the epitympanic recess (Fig. 206) and which articulates by an oblong, subdivided and slightly concave surface, with the

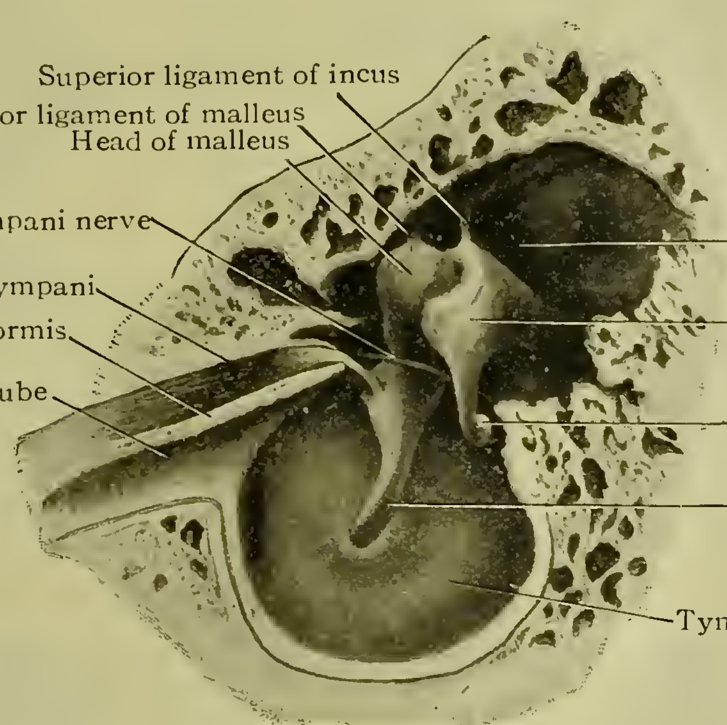

FIG. 206.—Inner aspect of outer wall of right tympanic cavity, showing incus and malleus and tympanic membrane in position. × 2½.

head of the incus; a *manubrium* or *handle*, related to the tympanic membrane as noted above; a *processus gracilis*, or *long process*, which should be followed from the constricted *neck* downward and forward to its entrance into the *Glaserian fissure* on the upper anterior part of the outer wall; a *processus brevis* springing from the outer aspect of the upper end of the handle to be connected with the tympanic membrane.

The **incus** (anvil) (Fig. 208) consists of a *body* which articulates by the two facets on its anterior-external surface with the head of the malleus and which is, therefore, like the latter, an occupant of the attic; of a *processus brevis* lodged in the fossa incudis of the posterior wall of the attic in relation with which it is held by the *posterior ligament of the incus;* of a *processus longus*, which passes downward and backward approximately parallel with the handle of the malleus to articulate by its small round end, the *processus orbicularis*, with the head of the stapes.

The **stapes** (stirrup) (Fig. 209) has a *head*, outwardly concave for articulation with the orbicular process of the incus and set off from the rest of the bone by the *neck;* two *crura*, the *anterior* and the *posterior*, which diverge from the neck; the *base* or *foot-piece* which is joined at each extremity by the corresponding crus and which fits into the oval window.

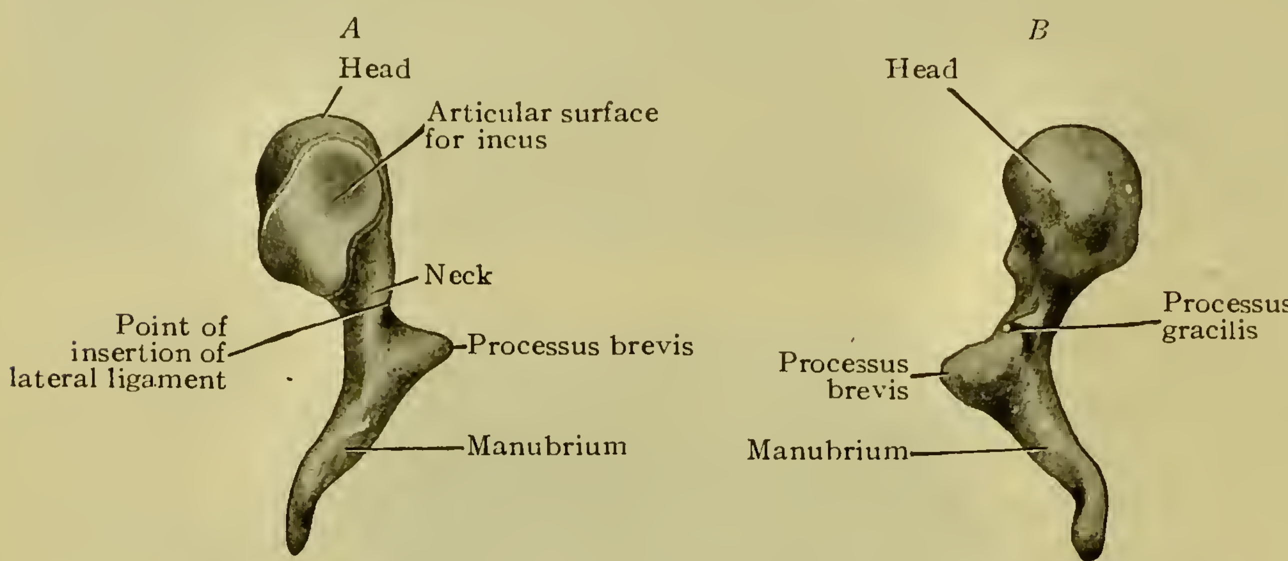

FIG. 207.—Right malleus: *A*, seen from behind; *B*, seen from in front. × 4½.

The **superior ligament of the malleus** will of course have been cut in removing the tegmen, to which it is attached above, but its attachment to the upper aspect of the head of the malleus can be noted.

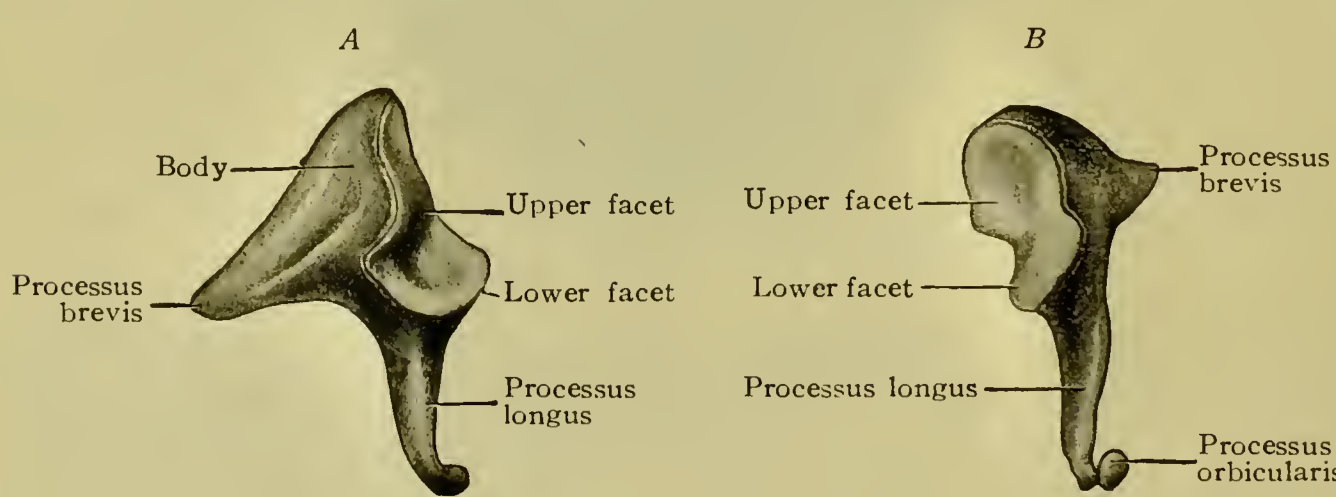

FIG. 208.—Right incus; *A*, lateral; *B*, anterior aspect. × 4½.

Now note the *capsular ligament* of the **malleo=incudal joint.** Incising it, note the layer of cartilage on each articular surface and the peculiar form of the latter. As pointed out by Politzer, when the handle of the malleus moves inward, the long process of the incus must do likewise, but when the manubrium moves outward, especially if to an unwonted degree, as in the case of great increase of tension within the tympanum, the lower cog of the malleus moves away from the incus and the latter moves but little. The **posterior ligament** of the incus

should be noted as connecting the short process of that bone with the posterior wall of the attic.

The **joint between the incus and stapes** can be best seen after making the bone-section referred to above.

The **tympanic orifice of the Eustachian tube** on the upper part of the anterior wall of the cavity should be identified by the introduction of a probe into it passed obliquely downward and forward.

The section of the bone referred to on page 442 should now be effected with care to avoid mutilation of the structures in relation with the outer wall as well as those on the inner wall of the cavity, the malleus and incus being separated and the saw carried down between them. The saw should not be allowed to incline inward, but should be kept in the vertical plane or inclined somewhat outward to insure its completing the section to the outer side of the styloid process and the stylomastoid foramen.

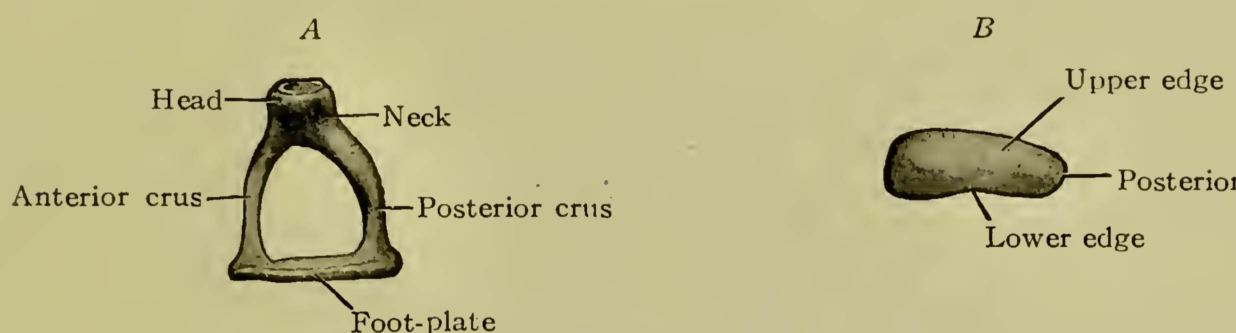

FIG. 209.—Right stapes; *A*, seen from above; *B*, mesial surface of foot-plate. × 4½.

The examination of the inner face of the outer wall of the tympanic cavity may now be completed.

As a preliminary to such examination, it is to be noted that the **mucous membrane** of the tympanum covers the ossicles and their ligaments, the stapedius tendon and the chorda tympani nerve in addition to clothing its walls, including the tympanic membrane. Necessarily, therefore, numerous **folds** are to be found, some of which are constant, while others are variable.

The **posterior malleolar fold** comes off from the margin of the notch of Rivinus and is attached to the handle of the malleus. Between this fold and the tympanic membrane is a recess, the **posterior pouch of Tröltsch.** Incising it in its long axis will reveal the chorda tympani nerve and the fan-shaped **external,** or **lateral ligament of the malleus.** The attachments of this ligament to the neck of the malleus and to the external wall of the tympanum above the notch of Rivinus should be made out. The *posterior fibres* of the external ligament are called the *posterior ligament of Helmholtz.* This external ligament of the malleus forms the lower boundary of the **pouch of Prussak,** its inner wall being the neck of the malleus and its outer wall the membrana flaccida.

The **anterior malleolar fold** leaves the tympanic membrane in front of the upper part of the handle of the malleus and passes forward. Between this fold and the tympanic membrane is a recess, the **anterior pouch of Tröltsch,** which opens downward. An incision into it and the careful separation of its two layers will disclose the *chorda tympani nerve*, the *processus gracilis* of the malleus and the *anterior ligament* of the malleus.

The **anterior ligament of the malleus** should be noted as being attached to the head and neck of the malleus and as dividing into two parts. One of these (anterior ligament of Helmholtz) is traceable to the spina tympanica major, i.e., the anterior margin of the Rivinian notch, while the other part (band of Meckel) envelops the processus gracilis and following it through the Glaserian fissure is attached to the spine of the sphenoid. This portion of the anterior ligament is what was at one time described as the *laxator tympani muscle*. The anterior and posterior ligaments of Helmholtz have been called the "axis ligaments of the malleus," since their point of attachment to the malleus corresponds with the axis about which it turns.

The **chorda tympani nerve** should be traced backward to the small aperture by which it enters the tympanic cavity, the **iter chordæ posterius.** The chorda arises from the facial nerve within the facial canal a short distance above the stylo-mastoid foramen and passes upward and forward to reach the aperture mentioned above. From this point it should be traced forward along the upper part of the tympanic membrane between its mucous and fibrous layers, across the inner surface of the handle of the malleus to the **iter chordæ anterius,** at the anterior limit of the external wall of the tympanum, through which it enters the canal of Huguier. Its emergence from the latter canal and its union with the lingual have been seen (p. 415).

The mucous membrane may now be entirely removed from the tympanic membrane to expose its fibrous layer.

The Posterior Wall of the Tympanum (paries mastoidea).—The **aperture of the antrum,** seen on the upper part of this wall, the **antrum** itself and the **fossa of the incus** have been seen (pp. 440 and 443).

The **styloid prominence,** produced by the upward prolongation of the styloid process, is sometimes seen just below the aperture of the iter chordæ posterius.

The **aperture of the iter chordæ posterius** has been examined in tracing the chorda; it is near the angle between the outer and posterior walls, almost as high as the upper limit of the membrane.

The **pyramid** is a small, hollow, conical eminence, with a perforation at its apex, which projects upward and forward. It contains the small **stapedius muscle,** the tendon of which emerges through the apical opening and passes forward to the stapes enveloped in a fold of mucous membrane (Fig. 210).

The Inner Wall of the Tympanum (paries labyrinthica).—The inner wall of the tympanic cavity corresponds with the outer wall of the internal ear (Fig. 210).

The foot-piece of the stapes, as mentioned above, fits into an aperture, the oval window, on the inner wall of the cavity, while its head articulates with the orbicular process of the incus. The **articulation between the stapes and the incus,** when examined, is seen to be provided with a *capsular ligament* which is lined with a *synovial membrane.*

The **fenestra ovalis** or **fenestra vestibuli,** the oval or vestibular window, is to be exposed by removing the stapes, the base of which is attached to the margin of the window by the *annular ligament.* The oval window is at the bottom of a depression, the *fossula fenestrae ovalis.* The oval window is an opening in the dried bone between the tympanum and the vestibule.

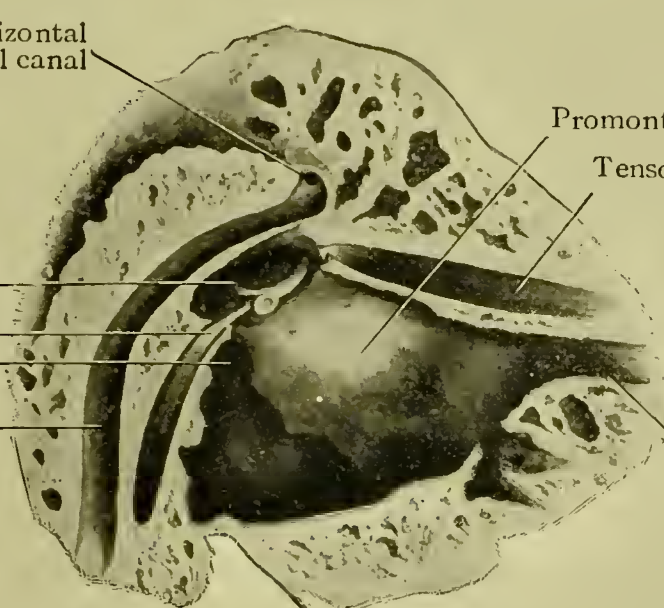

FIG. 210.—Outer aspect of inner wall of right tympanic cavity; stapes lies within oval window. × 2½.

The **promontory** is seen as a conspicuous bulging below and in front of the oval window produced by the first turn of the cochlea of the internal ear. The **tympanic plexus** is to be found in the mucous membrane covering it.

The **fenestra rotunda** (fenestra cochleæ), the round or cochlear window, at the bottom of a depression, the *fossulæ fenestræ cochleæ,* is below and behind the oval window, separated from it by the promontory. It is closed by the **secondary tympanic membrane** and leads from the tympanum into the cochlea.

The **ridge of the facial canal** should be recognized along the upper part of this wall; at the back of the tympanum the canal turns downward to terminate at the stylo-mastoid foramen. It has been partly opened in making the bone section. In the front and upper part of the inner wall is the dorsal end of the thin plate of bone that separates the

Eustachian tube from the canal for the tensor tympani, the **processus cochleariformis.** Prolonged backward a short distance, it ends in a hook, the *rostrum*, which serves as a pulley for the tendon of the tensor tympani.

The Anterior Wall of the Tympanum (paries carotica).—The lower part of the anterior wall of the tympanum is identical with the posterior wall of the carotid canal.

The **orifice of the Eustachian tube** at the upper part of the anterior wall the dissector has already examined. The **canal for the tensor tympani muscle** (semicanalis m. tensoris tympani) is above the Eustachian and is imperfectly separated from it by the processus cochleariformis, which, as seen in examining the inner wall of the tympanum, terminates near the fenestra ovalis in a hook or pulley for the tendon of the tensor tympani.

The **canaliculi caroticotympanici** are below the orifice of the Eustachian tube; they transmit from the carotid canal the tympanic branch of the internal carotid artery and the carotico-tympanic nerves.

The bony canal which contains both the Eustachian tube and the canal for the tensor tympani is the **canalis musculo-tubarius.** It is roofed in by the forward continuation of the tegmen tympani.

The **tensor tympani muscle** *arises* from the upper aspect of the cartilage of the Eustachian tube and the adjacent surface of the great wing of the sphenoid; it is *inserted* into the upper end of the handle of the malleus. Its tendon, having turned around the rostrum of the cochleariform process, approaches the malleus from the inner wall of the tympanum and thus is enabled to pull the manubrium inward and with it the tympanic membrane. Its *nerve-supply* is from the otic ganglion (Fig. 196).

With a director or a probe in the Eustachian tube as a guide, the bony roof of the canalis musculo-tubarius may be cautiously cut with a curved saw or broken by a chisel to expose the tensor tympani and the cochleariform process.

The **Eustachian tube** (p. 438) is a canal one and a half inches long, which passes forward and a little downward and inward from its posterior orifice on the anterior wall of the tympanum to terminate on the lateral wall of the naso-pharynx (Fig. 215). The upper third or *tympanic portion* has bony walls—this should be examined in the dry bone—while the remaining two thirds are partly enclosed by a curled or rolled plate of cartilage. This cartilaginous portion of the tube will be seen in studying the pharynx (p. 461). The tube is lined with ciliated columnar epithelium.

The Inferior Wall of the Tympanum (paries jugularis).—The floor of the tympanum corresponds with a part of the jugular fossa. Note

that it is narrower than the roof, that it may be below the level of the tympanic membrane and that it contains a small canal, the **tympanic canaliculus,** for the entrance of Jacobson's nerve, the tympanic branch of the glosso-pharyngeal.

The relation of the floor of the cavity to the jugular fossa and consequently to the bulb of the internal jugular vein and the fact that the bone here may be deficient, expose the vein to the risk of *infection* in middle ear disease and to *injury* in incision of the tympanic membrane (p. 442).

The **superior wall or roof of the tympanum** (pars tegmentalis) has been sufficiently considered (p. 439).

The **muscles of the tympanum** are the *tensor tympani*, which has been dealt with (p. 448), and the *stapedius*.

The **stapedius** *arises* within the pyramid (p. 446), from which its tendon emerges through the aperture in the apex to pass to its *insertion* on the head of the stapes. Its *nerve-supply* is a branch from the facial. Its *action* is to pull the head of the stapes backward, thus tilting the anterior end of the foot-plate outward.

The **blood-supply** of the tympanum is from the tympanic branch of the internal maxillary (Fig. 195), the tympanic branch of the internal carotid, the stylo-mastoid of the posterior auricular, the middle meningeal and the ascending pharyngeal.

The **nerve-supply** includes the tympanic branch of the glosso-pharyngeal for the mucous membrane; sympathetic fibres from the carotid plexus; motor fibres for the stapedius from the facial and for the tensor tympani from the otic ganglion.

What was said regarding the applied anatomy of the mastoid cells (p. 441) applies with equal force to the tympanum.

THE INTERNAL EAR.

Because of the complexity of its arrangement, the internal ear is called the *labyrinth*. The labyrinth consists of a series of spaces channelled out of the petrous portion of the temporal bone. These bony spaces are known as the **bony labyrinth** in contradistinction to a set of membranous cavities contained within them which are a modified reproduction of the bony labyrinth on a smaller scale and which are called the **membranous labyrinth.** The space between the outer surfaces of the membranous labyrinth and the walls of the bony labyrinth is the **perilymphatic space** and contains a fluid, the *perilymph* or *liquor Cotunii.* This space is, from the standpoint of its development, a lymph-space. The space enclosed by the membranous labyrinth is the *endolymphatic space* and contains a fluid, the *endolymph.* It differs essentially in character from the other space, being lined with epithelial cells which have originated from the surface ectoderm by a process of invagina-

tion and which are highly specialized in certain regions to form the end-organs of the cochlear and vestibular portions of the auditory nerve.

The Osseous Labyrinth.—The osseous labyrinth consists of a central cavity, the *vestibule*, of three *semicircular canals* opening into the latter, and of a spirally wound tube, the *cochlea*, which also is in communication with the vestibule.

The relative positions of these parts should be noted. The vestibule is the small ovoid cavity (Fig. 204) between the inner wall of the tympanum and the outer end of the internal auditory meatus as seen in the section. In front, it is continuous with the cochlea; behind, with the semicircular canals.

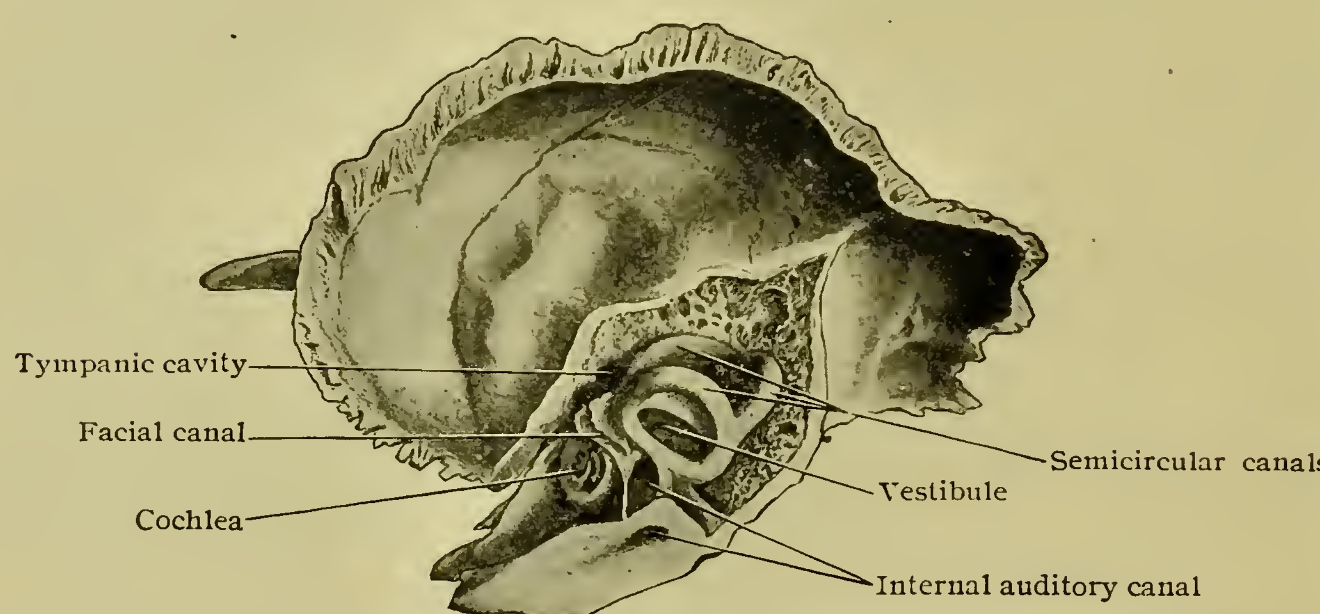

Fig. 211.—Right temporal bone; upper part of petrous portion has been removed to show bony labyrinth lying in position.

The Semicircular Canals.—The three semicircular canals open into the back part of the vestibule by five orifices, two of the canals having one opening in common. Each canal has an enlargement at one of its ends called the *ampulla* and describes two thirds of a circle or a little more; the plane of each forms a right angle with the plane of each of the other two.

The **superior canal** is placed in the vertical plane and at a right angle with the long axis of the petrous portion of the temporal bone, its upper limit corresponding to the convexity on the upper surface of this bone already noted (p. 439). Being cut twice in a horizontal section of the bone, its openings—one twentieth of an inch in diameter—are seen in Figure 204. Its *ampulla* belongs to the outer limb and opens into the upper part of the vestibule; the end of the inner limb opens in common with one limb of the posterior canal into the upper inner part of the vestibule.

The **posterior canal** is also in the vertical plane, but this plane is nearly parallel with the long axis of the petrosa. Its *ampulla* opens into the lower back part of the vestibule; the other limb ends in common with that of the superior canal as mentioned above.

The **external canal** is in the horizontal plane. Its *ampulla* is at the upper outer part of the vestibule, its opposite opening being at the upper and back part of that cavity.

Each of these canals contains a smaller *membranous canal* which is identical with the bony canal except as to its *diameter*, which is one third that of the bony canal.

Some further idea of these canals and of the cochlea and vestibule may be obtained by making additional sections through the petrosa with a fine saw if another bone or skull be available. One such section, for example, may be in the vertical plane corresponding with the long axis of the petrosa; it will cut the posterior and external canal and the cochlea.

The Cochlea.—The cochlea, resembling a snail-shell in general form, consists of a bony **tube** wound spirally two and three fourths times around a central axis, the **modiolus** or **columella.** The **modiolus** tapers from its large end or base to its apex. The bony tube of the cochlea is also larger in its first turn, the **basal coil,** at the base of the modiolus, and becomes gradually smaller towards the apex of the latter, its last turn or **apical coil** terminating blindly as the **cupola.**

The **bony lamina spiralis** is a projecting plate or ledge attached by one border to the modiolus in a spiral line which corresponds with the turns of the tube of the cochlea and projects into the lumen of this tube so as to partially divide it into two tubes or passage-ways called **scalæ;** the division is completed by the **membrana basilaris,** which stretches from the outer free border of the lamina to the outer wall of the tube of the cochlea. Supposing the cochlea to be set upon its base, the modiolus being vertical, the upper passage-way is the **scala vestibuli,** the lower, the **scala tympani.**

The cochlea *in situ* does not stand upon its base but lies upon its side, the long axis of the modiolus being directed forward and outward. The **base** of the modiolus corresponds to the fore part of the lamina cribrosa at the outer end of the internal auditory meatus, while the **apex** is near the canal for the tensor tympani muscle. It lies just in front of the vestibule, with which the scala vestibuli comes into immediate relation; the basal coil is also in relation with the inner wall of the tympanum, producing here the promontory.

The membranous portion of the cochlea is the **cochlear duct;** this is cut off from the scala vestibuli by the **membrane of Reissner,** which stretches from the upper surface of the bony spiral lamina to the outer wall of the tube of the cochlea. The cochlear duct is a part of the endo-

lymphatic space and is lined with epithelium some of which has become specialized to form the organ of Corti; the scalæ vestibuli et tympani belong to the perilymphatic space and contain perilymph.

The modiolus contains a **central canal** for the branches of the cochlear nerve that go to the apical coil of the cochlea and many smaller canals; the inner margin of the spiral lamina encloses a spiral canal, the **canalis spiralis,** for the ganglion spirale of the cochlear nerve.

The Vestibule.—The vestibule (Fig. 211) is an ovoid cavity having its long axis fore and aft and measuring in this diameter one fifth of an inch, while its vertical and transverse diameters are each one eighth of an inch.

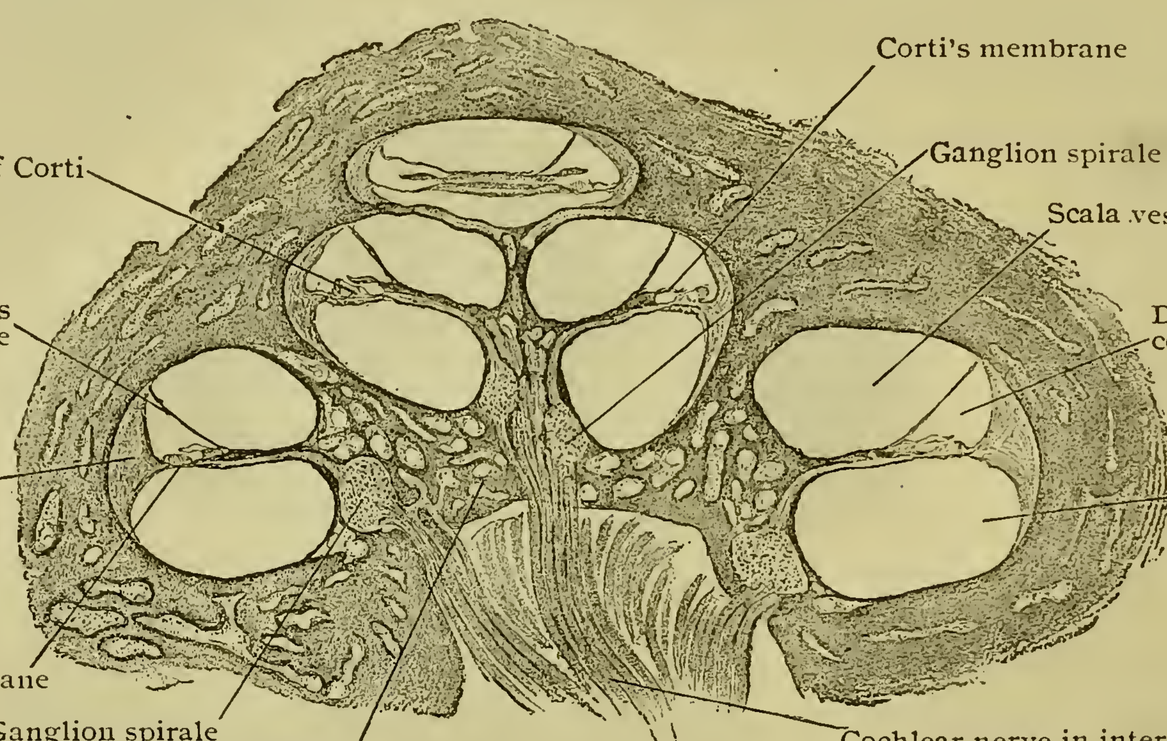

FIG. 212.—Section of human cochlea passing through axis of modiolus. × 12.

Its **outer** or **tympanic wall** corresponds with a part of the inner wall of the tympanum and communicates, in the dried bone, with the tympanum through the fenestra ovalis or vestibular window, closed in the recent state by the foot-plate of the stapes. Verify this by passing a probe through the fenestra from the tympanic side, with caution to avoid injuring the vestibule.

The **posterior wall** of the vestibule—it must be understood that there are no sharp lines of distinction between the " walls " of the vestibule, since it is of modified globular shape—receives the *five openings* of the three semicircular canals. One of these canals is shown in the horizontal section, its two limbs being cut transversely (Fig. 204).

The **anterior end** of the vestibule presents an oval orifice, the *aperture of the vestibular scala of the cochlea* (apertura scalæ vestibuli cochleæ), through which the vestibule communicates with that part of the cochlea

known as its *vestibular scala* because of this communication. As will be seen later, this aperture transmits a small fibrous canal, the cochlear duct (Fig. 212), which projects through it from the cochlea into the vestibule. The opening may be carefully sought with a small probe passed through the vestibule.

The **roof** of the vestibule has been removed. It corresponds to that part of the upper and anterior surface of the petrosa which is internal to and in front of the previously noted eminence caused by the superior semicircular canal. On the under surface of the roof is part of the hemi-elliptical fossa or **recessus ellipticus.**

The **floor** of the vestibule corresponds with the part of the under surface of the petrosa adjacent to the inferior opening of the carotid canal. The small aqueductus cochleæ, for the transmission

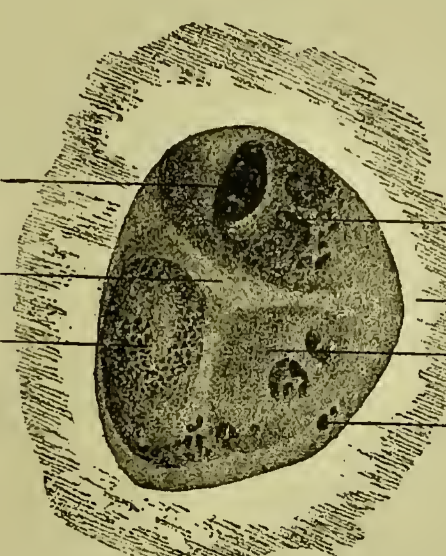

FIG. 213.—Bottom of right internal auditory meatus. × 5.

of a vein, leads from the vestibule to the surface of the petrosa above noted.

The **inner wall** of the vestibule should be studied in connection with the lamina cribrosa, with a portion of which it corresponds, and also in connection with the portions of the membranous labyrinth contained within the vestibule. These are the two little sacs, the **saccule** and the **utricle,** which are indirectly in communication through the Y-shaped **ductus endolymphaticus.** The common limb of the latter duct is prolonged into the **aqueductus vestibuli,** which begins on the back part of the inner wall and terminates on the posterior surface of the petrosa where the dilated **saccus endolymphaticus** comes into relation with the dura mater. The larger **utricle** receives the five orifices of the membranous semicircular canals, while the smaller **saccule** is connected by the narrow **canalis reuniens** with the cochlear duct (scala media). Thus all parts of the membranous labyrinth constitute one system of spaces containing the endolymph.

Comparing the inner wall of the vestibule with the lamina cribrosa, it is seen that the superior cribriform area of the lamina corresponds with the **macula cribrosa superior,** *i.e.*, the collection of apertures on the **crest** and in the **recessus ellipticus** through which branches of the vestibular nerve reach the utricle and the ampullæ of the superior and external canals. Note also that the foramina below the back part of the falciform crest of the lamina cribrosa coincide with the **macula cribrosa media** in the **spherical fossa** for the transmission of the branches of the vestibular nerve that supply the saccule. The openings in the larger cribriform area below the front part of the falciform crest transmit the cochlear nerves to the modiolus and the basal coil of the cochlea.

The **membranous labyrinth** includes, as pointed out above, the *membranous semicircular canals*, the *saccule*, the *utricle*, the *ductus endolymphaticus*, the *canalis reuniens* and the *cochlear duct.*

The **cochlear division** of the auditory nerve is the real nerve of hearing. Its fibres are the axones of the cells of the **ganglion spirale** contained within the spiral canal of the lamina spiralis, the dendrites of which pass to the organ of Corti; the axones terminate in the ventral and lateral cochlear nuclei of the medulla.

The **vestibular division** of the nerve supplies the **maculæ** of the utricle and saccule and the **cristæ acusticæ** of the semicircular canals. The **ganglion of Scarpa** in the internal auditory canal consists of cells whose axones make up the vestibular nerve and which terminate in the vestibular nuclei of the medulla.

The **blood=supply** of the internal ear is from the internal auditory artery and the stylo-mastoid artery.

The Facial Nerve.—The origin of this nerve and its entrance into the internal auditory canal in company with the auditory nerve and artery and the pars intermedia have been seen (p. 330). Its distribution upon the face has also been followed (p. 393). It should now be traced in its course through the temporal bone.

Leaving the internal auditory meatus through the aperture in the upper anterior part of the lamina cribrosa (Fig. 213), it enters the facial canal or aqueductus Fallopii and follows this canal to its termination at the stylo-mastoid foramen. As seen in the section and in Fig. 204, it passes at first forward and slightly outward for about one third of an inch and then turns sharply backward. At this angle or *knee* it presents an enlargement, the **geniculate ganglion** or **intumescentia ganglioformis.** To this point in its course the nerve is accompanied by the *pars intermedia* or *nervus intermedius*, which is seen to end in the geniculate ganglion. Following the nerve as it passes backward from the ganglion, it is seen to run along the upper part of the inner wall of the tympanum (Fig. 210) and then to bend vertically downward back of the tympanum toward the termination of the facial canal.

The **branches of the facial nerve in the Fallopian canal** are the *great superficial petrosal*, a part of the *small superficial petrosal*, the *external superficial petrosal*, from the geniculate ganglion; the *stapedial*, the *chorda tympani* and a *communicating branch* to the *vagus* from the trunk of the nerve.

The **great superficial petrosal nerve** should be traced forward through the hiatus Fallopii, the bone which covers the small canal usually being so thin as to be easily broken away. The further course of the great superficial petrosal has been followed (pp. 336 and 433). An effort should be made to find the small branch of the tympanic plexus which joins it in the hiatus Fallopii.

The **small superficial petrosal nerve** is formed by the union of a branch from the geniculate ganglion and a branch from the tympanic plexus of the glosso-pharyngeal. The former is sometimes described as the *communicating branch to the tympanic plexus* (r. anastomoticus cum plexu tympanico), since it enters the tympanum and there joins the branch of the tympanic plexus to form the small superficial petrosal. The latter leaves the tympanic cavity through a small canal beneath the canal for the tensor tympani, which conveys it to the anterior surface of the petrous portion of the temporal bone just external to the hiatus Fallopii, from which point it passes forward to leave the cranium through a canal in the greater wing of the sphenoid or through the suture between the greater wing and the petrous portion of the temporal.

The **external superficial petrosal nerve,** not always present, joins the sympathetic plexus of the middle meningeal artery.

The **tympanic** or **stapedial branch** arises from the facial in the vertical part of the facial canal and passes forward into the pyramid to supply the stapedius muscle.

The **chorda tympani** arises from the facial near the termination of the facial canal. Its course through the tympanic cavity has been seen (p. 446) as well as its further course and union with the lingual nerve (p. 415), with which latter it is distributed, some of its *motor* (facial) fibres going to the submaxillary ganglion as its motor root, the *sensory fibres* (from the geniculate ganglion) going to the mucous membrane of the anterior two thirds of the tongue on its dorsum and sides.

The other branches of the facial nerve have been dissected with the structures of the face (p. 393).

The facial nerve was formerly regarded as a motor nerve, the pars intermedia, or nervus intermedius, which accompanies it into the facial canal and joins the geniculate ganglion of the facial, being looked upon as being made up of glosso-pharyngeal fibres which, after a short course with the facial, left it as a part of the chorda tympani to go by way of that nerve to the lingual branch of the trigeminus and so to the tongue.

Regarding the facial nerve as a mixed nerve, the nervus intermedius

or pars intermedia of Wrisberg is to be looked upon as its sensory root. The axones of the cells of the geniculate ganglion pass centripetally through the nervus intermedius to terminate by arborizing about the cells of the glosso-pharnygeal nucleus; the dendrites of the geniculate ganglion cells constitute those fibres that pass centrifugally—in the anatomical sense, though functionally afferent fibres—through the chorda and the lingual nerve to the tongue.

The great and a part of the small superficial petrosal nerves, though classed as branches of the geniculate ganglion, contain chiefly motor fibres derived from the facial—motor fibres to the spheno-palatine and otic ganglia respectively—with which are mingled some sensory fibres from the ganglion (p. 416).

Spasm of the facial muscles from irritation of the facial nerve or its centre is known as convulsive tic or *tic convulsif* (painful tic, *tic douloureux*, is neuralgia of the trifacial nerve).

Facial paralysis occurs rarely as a *monoplegia* from a cortical lesion of the face-centre; as a part of *hemiplegia* from a lesion of the internal capsule (p. 533); as a part of *alternate* or *crossed hemiplegia* from a lesion of the pons (p. 547); or as *Bell's palsy*, from a lesion of the nerve itself.

Bell's palsy may result from *intracranial lesion*, as pressure by tumors; from injury or pressure *in its course through the facial canal of the temporal bone*, as middle ear disease or fracture of the temporal; or injury or disease of the *extra-cranial portion of the nerve.*

The symptoms of Bell's palsy are to be interpreted by recalling the distribution of the nerve. From elimination of its motor function, there are:—

Paralysis of the muscles of expression: smooth and expressionless appearance of the affected side of the face, the mouth being drawn to the opposite side; lagophthalmos, *i.e.*, inability to close the eye, resulting in epiphora, or overflow of the tears upon the cheek, and imperfect protection of the conjunctiva, bringing about conjunctivitis; from failure of the tears to enter the canaliculi the nasal mucous membrane may become unduly dry with possibly consequent impairment of the sense of smell; dribbling of saliva and accumulation of food in the vestibule of the mouth during mastication (paralysis of orbicularis oris and buccinator).

Paralysis of the stapedius, causing interference with hearing (if the lesion is in the temporal bone or in the cranium).

From elimination of the sensory fibres (if the lesion is on the proximal side of the origin of the chorda tympani) loss of taste in the anterior two thirds of the tongue.

THE PHARYNX AND THE CERVICAL PORTION OF THE ŒSOPHAGUS.

THE EXTERNAL ASPECT AND RELATIONS OF THE PHARYNX.—To demonstrate the **form** of the pharynx its cavity may be moderately distended with tow or cotton or strips of gauze passed through the mouth. It is then seen to be a sac measuring about five inches in length and four and one-half inches transversely at its widest part opposite the greater cornua of the hyoid bone and tapering below to the width of the œsophagus, with which it becomes continuous at its termination at the

lower border of the fifth cervical vertebra. Its upper limit is the base of the skull or more exactly the under surface of the body of the sphenoid and of the basi-occipital. To afford a better view of the lateral aspect, the internal pterygoid muscle may be divided except for its anterior fourth. In reflecting the muscle, do not disturb the lingual nerve on its outer surface (Fig. 192) nor the levator palati muscle in relation with its deep surface. After noting the stylo-pharyngeus muscle (p. 379), note the **pharyngeal fascia** as the most superficial constituent of the pharyngeal wall. The **pharyngeal fascia** or **bucco=pharyngeal fascia** has been seen in part as covering the outer surface of the buccinator (p. 400).

The **lateral relations** of the pharynx to the internal and common carotid arteries, to the internal jugular vein, the styloid process and the muscles and ligaments attached to it, the glosso-pharyngeal, hypoglossal, lingual, spinal accessory and vagus nerves, the pharyngeal nerve-plexus and the ascending pharyngeal artery, have been seen in the dissection of the neck, but should be again examined. The **pharyngeal venous plexus** should also be sought on the lateral and posterior aspects.

The **retro=pharyngeal space** between the bucco-pharyngeal fascia on the posterior wall of the pharynx and the prevertebral fascia on the front of the prevertebral muscles should be noted.

The bucco-pharyngeal fascia should be removed by careful dissection in the direction of the muscular fibres.

The **muscular tunic** of the pharynx will be exposed by the removal of the bucco-pharyngeal fascia. It is constituted chiefly by the three pharyngeal constrictors supplemented by the stylo-pharyngeus and the palato-pharyngeus.

The Inferior Constrictor of the Pharynx (Fig. 197).—**Origin,** the side of the cricoid cartilage and the ala of the thyroid cartilage upon and behind the oblique line; **insertion,** a posterior median raphe; **nerve=supply,** the pharyngeal plexus.

Note the upward and backward direction of the fibres and that the upper border overlaps the middle constrictor. Near the upper border are the superior laryngeal nerve and the superior thyroid artery, while the recurrent laryngeal nerve and the inferior laryngeal artery pass upward beneath its lower border, and the common carotid artery is in relation with its outer surface.

The Middle Constrictor of the Pharynx (Fig. 197).—**Origin,** the greater and lesser cornua of the hyoid bone and the stylo-hyoid ligament; **insertion,** a posterior median raphe; **nerve=supply,** the pharyngeal plexus.

Note the direction of the fibres and that the lower border of the muscle is overlapped by the inferior constrictor while its upper border overlaps the superior constrictor, the glosso-pharyngeal nerve, the stylo-pharyngeus muscle and the stylo-hyoid ligament passing under

the upper border between it and the superior constrictor. In relation with its outer surface are the pharyngeal plexus, the lingual artery and vein and the carotid vessels.

THE SUPERIOR CONSTRICTOR OF THE PHARYNX (Fig. 197).—**Origin,** the inner surface of the alveolar process of the mandible above the rear extremity of the mylo-hyoid ridge, the pterygo-maxillary ligament, the lower third of the free border of the internal pterygoid plate and its hamulus and the contiguous portion of the palate bone; **insertion,** a posterior median fibrous raphe and, by an aponeurosis, the pharyngeal tubercle of the basi-occipital; **nerve=supply,** the pharyngeal plexus.

Displacing the internal pterygoid as directed on page 457, the origin of the muscle may be seen and the direction of its fibres noted. Its relation to the middle constrictor below and the structures passing between the two muscles are noted in a preceding paragraph. Note that the upper border of the muscle does not reach to the base of the skull and that in the interval thus left, the sinus of Morgagni, the *third tunic* of the pharynx, the **pharyngeal aponeurosis,** is exposed. Note also in relation with the outer surface the internal pterygoid muscle, the lingual, hypoglossal, spinal accessory, vagus and glosso-pharyngeal nerves and the internal carotid and ascending pharyngeal arteries.

THE CERVICAL PORTION OF THE ŒSOPHAGUS.—The œsophagus or gullet begins at the lower end of the pharynx opposite the lower border of the fifth cervical vertebra. Following it in its course down the neck in front of the precervical muscles and behind the trachea, it is seen to follow the curve of the cervical spine but to present an additional curve, a slight deviation to the left side. Unlike the trachea, the œsophagus is a collapsed tube.

The **relations of the œsophagus in the neck** should be noted. On each side it is related with the deeper portions of the lateral lobes of the thyroid gland and with the carotid sheath, but more closely on the left side than on the right because of its deviation. In front are the trachea and the recurrent laryngeal nerves and, at the root of the neck, the thoracic duct; behind, it rests upon the longus colli muscles and the spine.

The **blood=supply** is from the inferior thyroid artery.

The **nerve=supply** is from the recurrent laryngeal and the sympathetic.

The œsophagus may be obstructed by the *impaction* of a swallowed *foreign body*, by *stricture*, which may be *spasmodic*, *fibrous* or *malignant;* or by *pressure* from without, as by *aneurism* or *tumor.*

External œsophagotomy, or cutting into the œsophagus from the outside, is done either to remove a foreign body or to relieve obstructive stricture. In the neck, this operation is done through an incision on the left side because of the left lateral deviation of the tube.

The cut and reflected internal pterygoid muscle should now be replaced and stitched. The internal jugular vein, and internal carotid artery, the ninth, tenth, eleventh and twelfth nerves and the styloid process should be cut near the base of the skull. Passing a doubled piece of cheese-cloth behind all these structures and behind the œsophagus and pharynx, they should be held forward while a transverse incision is made through the periosteum upon the under surface of the basilar process of the occipital a half-inch in front of the anterior margin of the foramen magnum, clearing the insertion of the anterior straight muscles. Applying the saw in this incision, the dissector should saw through the basilar process, working the saw in a plane parallel with the long axis of the neck. When the saw begins to nick the middle root of the zygoma on each side, just clearing the front wall of the external meatus, it may be withdrawn and applied above in the same plane in such position as to cut through the basilar process from the cranial surface about midway between the margin of the foramen magnum and the dorsum ephippii. The anterior half of the section is now to be removed, after cutting the vessels, the trachea and the œsophagus at the root of the neck. Protecting the posterior half of the section with damp cloths for further dissection, the examination of the pharynx should be continued.

THE EXTERIOR RELATIONS OF THE PHARYNX (continued).—The **ascending pharyngeal artery** (Fig. 229) should first be sought and its course and branches noted (p. 371). On the posterior surface, the interlacing of the pharyngeal constrictors of the two sides in the median raphe should be noted (Fig. 214).

The Connections of the Pharynx.—Inspecting the organ from behind, note its attachment to the basilar process (insertion of the superior constrictor into the pharyngeal tubercle) and to the Eustachian tube and petrous portion of the temporal; at the side, its connection with the ramus of the mandible, the pterygo-mandibular ligament and internal pterygoid plate (origin of superior constrictor); with the styloid process by the stylo-pharyngeus; its attachment to the cornua of the hyoid bone (middle constrictor) and to the larynx (inferior constrictor).

Now removing the stuffing from the pharynx through the mouth cavity, note the collapse of the rear wall toward the front and the relatively short antero-posterior diameter.

THE INTERIOR OF THE PHARYNX.—The cavity of the pharynx is to be laid open by a posterior median vertical incision (Fig. 215). The inner face of the anterior wall thus exhibited presents four apertures, the *two posterior nares* or *choanæ* above corresponding to the **naso-pharynx**; below these, the *isthmus of the fauces* or *oral opening* corresponding with the **oro-pharynx**; and farther down, in the **laryngo-**

pharynx, the *laryngeal opening*. The other openings are the *œsophageal* at the lower end and a *Eustachian aperture* on each side above.

The **soft palate,** terminating as the uvula, depends from the posterior margin of the hard palate between the posterior nares and the fauces. Stitching the tip of the uvula to the back part of the tongue, an attempt

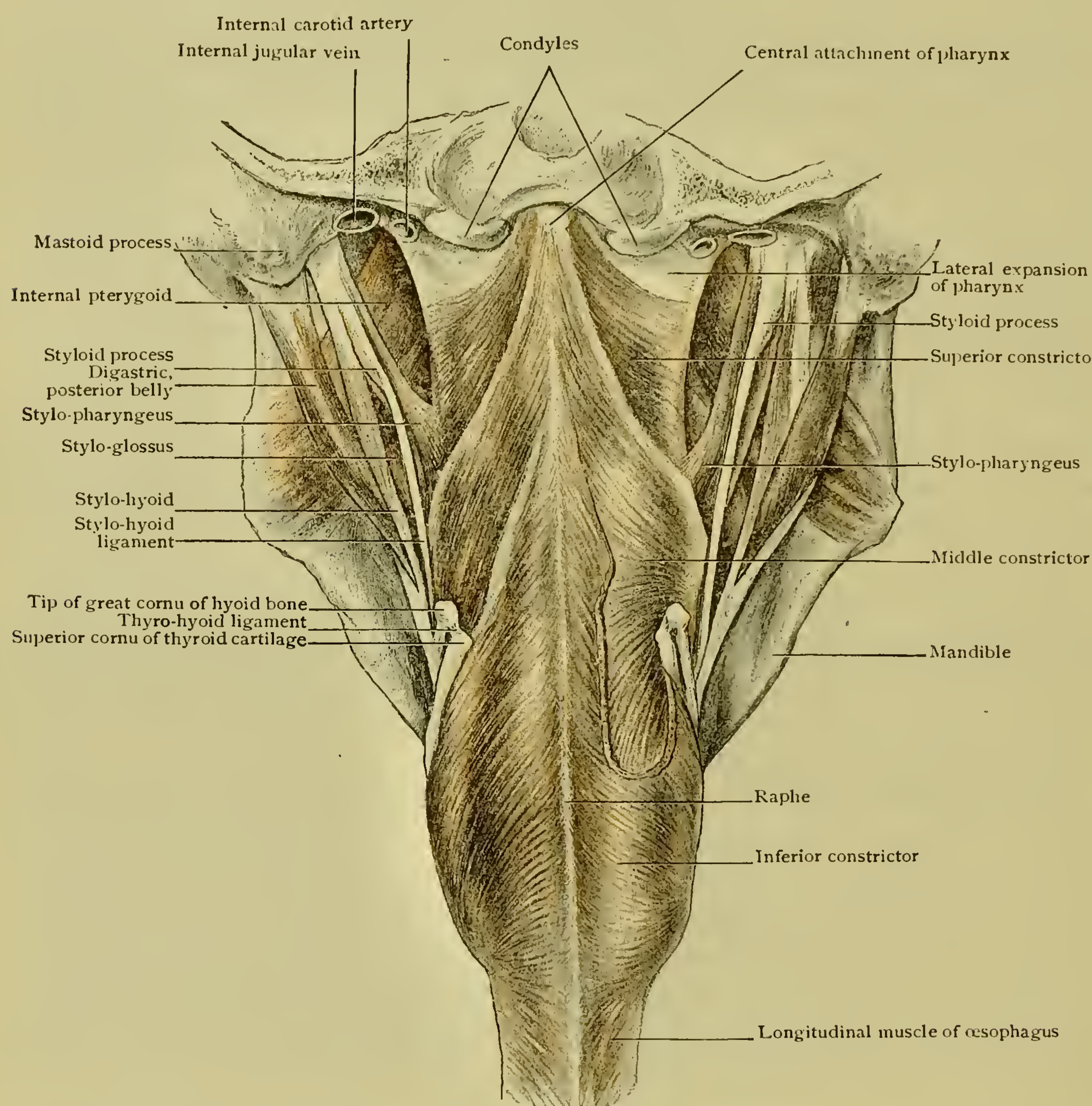

FIG. 214.—Muscles of pharynx from behind; portion of inferior constrictor has been removed.

may be made to dissect the *mucous membrane* from its naso-pharyngeal surface and to demonstrate the *posterior fasciculus of the palato-pharyngeus* muscle. Beneath this attenuated stratum, a successful dissection would show in succession the *salpingo-pharyngeus* and *azygos uvulæ*, the *levator palati*, the thicker *anterior fasciculus of the palato-pharyngeus*, the *tensor palati* and the *palato-glossus*, the last being in relation with the *mucous membrane* of the oral side of the soft palate.

The **lateral wall of the naso-pharynx** should be examined (Fig. 215). It will be more easily seen after the sagittal section of the skull.

The **naso-pharyngeal fold** is the ridge passing from the base of the skull downward to the attachment of the soft palate and marking the distinction between the naso-pharynx and the nasal chamber.

The **pharyngeal orifice of the Eustachian tube** (Fig. 215) is seen on the upper anterior part of the lateral wall on the level of the inferior turbinated bone; note the small *anterior lip* of this orifice and the much *larger posterior* lip or *Eustachian cushion* (torus tubarius) and the deep *fossa of Rosenmüller* or the *lateral recess* of the pharynx behind the cushion. Note, too, the velvety appearance of the mucous membrane about the orifice due to nodules of lymphoid tissue, the **tubal tonsil.** The **salpingo-pharyngeal fold** containing the muscle of the same name, the posterior fibres of the palato-pharyngeus, which arise from the Eustachian cartilage, passes downward from the Eustachian cushion and gradually fades away.

The Eustachian catheter is passed into the tube through the inferior meatus of the nose, the Eustachian cushion serving as a guide to the orifice by arresting the beak of the instrument when the latter is turned outward.

The **roof of the naso-pharynx,** formed by the body of the sphenoid and the basilar process of the occipital, presents a collection of lymphoid tissue, more abundant in childhood, the **pharyngeal tonsil** (p. 473). It stretches between the Eustachian orifices and presents in the mid-line a *recess* often called the *pharyngeal bursa.* This is not to be confused with the very rarely present *pocket of Rathke*, the remnant of the hypophysial diverticulum.

The **lateral wall of the oro-pharynx** is delimited from the mouth cavity by the **anterior pillar of the fauces,** or **anterior palatine arch** containing the **palato-glossus muscle.** The archway bounded laterally by the anterior pillars is the **isthmus faucium,** the aperture of communication between the mouth and the pharynx. Back of the anterior pillar is the **posterior pillar of the fauces** or **posterior palatine arch** (Fig. 215) containing the **palato-pharyngeus muscle.** The **recess** between the anterior and posterior pillars contains the **tonsil** (the faucial tonsil), the fossa above the tonsil being the **supra-tonsillar fossa.**

The Tonsil (Fig. 215).—Note the numerous openings on the surface of the tonsil, the **crypts,** which are lined with prolongations of the pharyngeal mucosa. With a blunt dissector loosen the tonsil as much as possible from the surrounding tissues. (This may be done more conveniently at a later stage (p. 468).) Note that its *position* corresponds with a point a little above and in front of the angle of the jaw just back of which swelling is perceptible in severe tonsillitis. Note also that the

ascending pharyngeal artery is in close proximity, being separated from the tonsil by the superior constrictor, while the internal carotid is from three fourths to one inch backward and outward.

The **blood=supply** of the tonsil is derived from the facial artery through the tonsillar and ascending palatine branches, and from the lingual, descending palatine and ascending pharyngeal arteries.

The **lymphatics** pass to the submaxillary nodes chiefly.

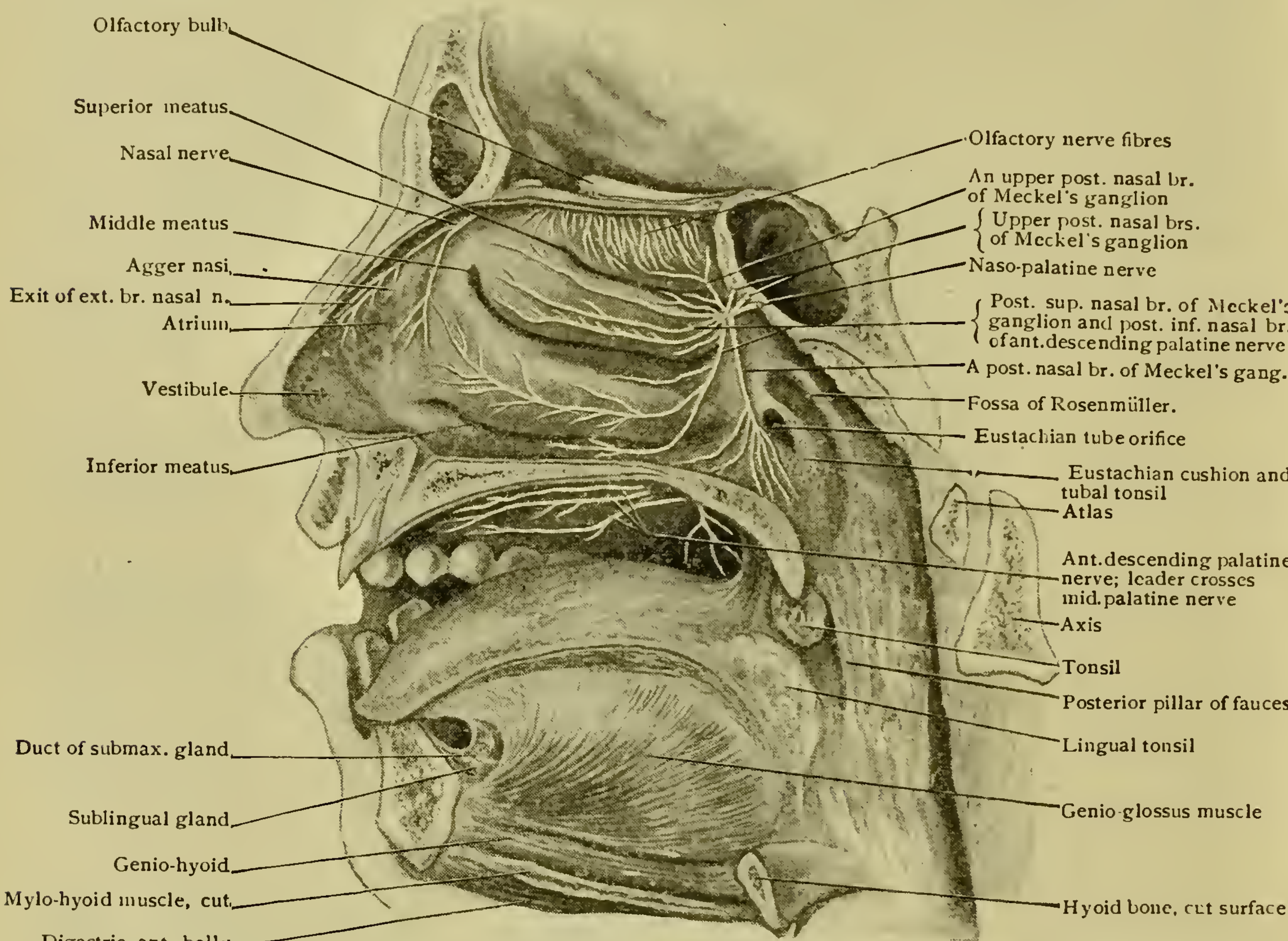

FIG. 215.—Mesial section of skull, showing oral cavity, right wall of pharynx and lateral wall of right nasal chamber.

In the **laryngo=pharynx** the aperture of the larynx should be noted as a triangular opening, the base of which is in front and is formed by the epiglottis. The depressed area on each side of the opening, between it and the wing of the thyroid cartilage, is the **sinus pyriformis.**

The **mucous membrane,** the innermost tunic of the pharynx, the gross features of which have just been studied, should be dissected to a slight extent to expose the underlying fibrous tunic, the **pharyngeal aponeurosis.** Thus the **layers of the pharyngeal walls** from without inward are the *bucco=pharyngeal fascia*, the *muscles*, the *aponeurosis* and the *mucosa*.

The **retro-pharyngeal space,** its communication with the sac of the parotid fascia and the resulting relation between retro-pharyngeal abscess and parotid abscess have been referred to (p. 403). Since this space is in front of the prevertebral fascia (p.364), the pus, in case of **retro-pharyngeal abscess,** may pass into the thorax. The early incision of retro-pharyngeal abscess is important not only for these reasons but because of the danger of suffocation from unexpected and unguarded spontaneous discharge of the pus into the pharynx and larynx.

THE MOUTH CAVITY.

THE ANTERIOR AND LATERAL BOUNDARIES OF THE MOUTH.—The **lateral boundaries** of the cavity of the mouth, the *cheeks* (buccæ), have been practically dissected and have been seen to consist of the buccinator and the sucking pad chiefly, supplemented by the risorius and the external covering of subcutaneous tissue and skin. The inner covering is the buccal mucous membrane and the buccal glands. The perforation of the cheek by the parotid duct has also been seen (p. 393).

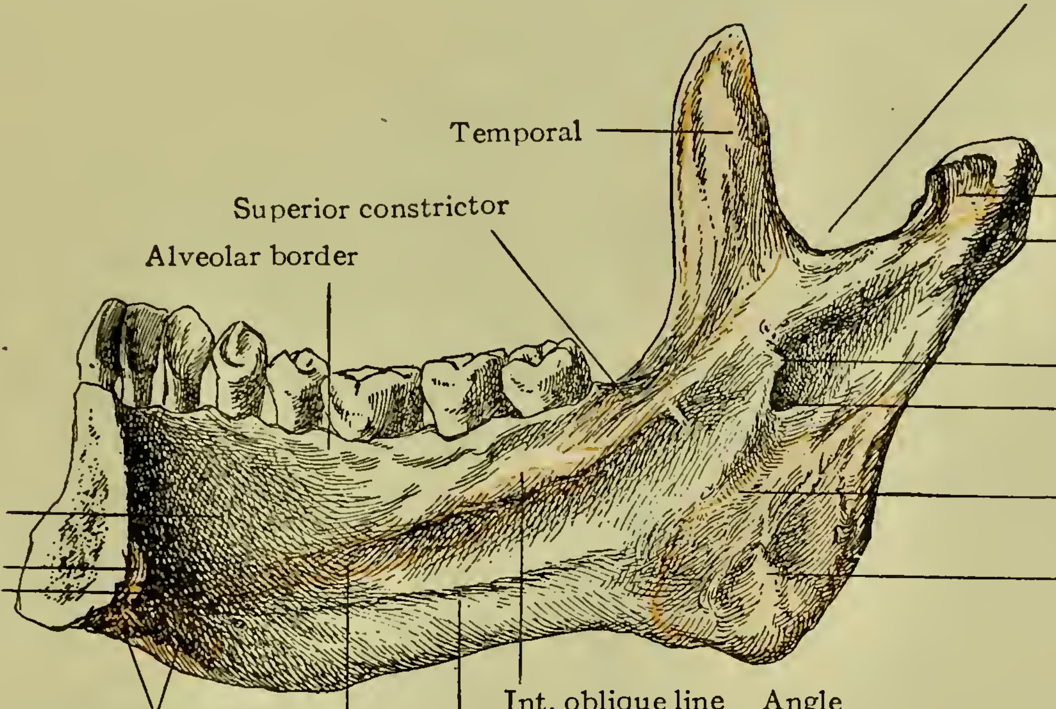

FIG. 216.—Inferior maxillary bone, inner aspect.

The **anterior boundaries,** the *lips*, have also been dealt with and their vascular and nerve-supply worked out (pp. 397 and 398). The lips should be everted and the **frenum** in each case noted as a vertical median fold of mucous membrane passing to the gum.

The **vestibule** of the mouth is the space bounded internally by the alveolar arches and teeth and externally by the cheeks and lips.

THE ROOF OF THE MOUTH.—The roof of the mouth is the hard and the soft palate. These may be examined superficially through the widely open mouth and preferably in the living subject. The **incisor**

pad at the anterior limit of the hard palate in the mid-line should be noted, as well as the dome of the palate and the inequalities in its surface. The nerves and vessels will be dissected later (p. 475). Inspection of the cavity from the front shows the **anterior palatine arches,** one on either side, bounding the isthmus of the fauces, continuous above with the soft palate and below with the side of the tongue (p. 461). The **recess of the tonsil** and usually the **tonsil** itself, and behind it the **posterior palatine arch** are also to be seen.

Defective union of the lateral nasal and maxillary processes with the globular processes of fetal life result in **harelip,** which is never median in position but always lateral for this reason, the line of union of the parts mentioned corresponding with the intermaxillary suture of the hard palate. Harelip is sometimes bilateral.

Cleft palate is often associated with harelip but may occur independently. It results from defective union of the palate shelves and may implicate only a part of the hard palate, or all of it, or may affect the soft palate and the uvula or the uvula alone (bifid uvula).

In the operation for cleft palate—**uranoplasty**—the mucous membrane and the periosteum, which are closely united, are dissected up from the under surface of the bone and brought together in the mid-line. **Staphylorrhaphy** is suturing a bifid uvula.

Paralysis of the soft palate, which may occur as a sequel of diphtheria, is attended with interference with articulation and with regurgitation of fluids through the nose in drinking, from inability of the soft palate to close the posterior nares.

The Floor of the Mouth.—The floor of the mouth is formed in front by the mylo-hyoid muscles supplemented by the genio-hyoid and the genio-glossus muscles; the space back of the mylo-hyoids is occupied by the root of the tongue.

With the mouth cavity open, the tip of the tongue should be drawn forward and upward and fastened with a stitch or two to the nose, to expose the **sublingual space.** The two elevations on the floor of this space are the sublingual glands covered with mucous membrane. The **orifice of the submaxillary duct** (Fig. 217) is on the apex of a small elevation near the mid-line. If the surface in the living subject be dried by pressing a dry cloth or cotton against it, the orifice and the escaping saliva are easily recognized upon abruptly removing the absorbing material. The **ducts of the sublingual gland** open in this region by minute orifices.

Retention cysts from obstruction of one or more of these ducts occur in this region, constituting **ranula.**

The under surface of the free part of the tongue presents the vertical median fold of mucous membrane, the **frenum linguæ,** abnormal shortness of which interfering with the movements of the tongue in sucking is known as *tongue-tie.*

Division of the frenum for the relief of tongue-tie, though a trivial operation, may be attended with copious bleeding; if the division is too free, the tongue may fall backward, embarrassing respiration.

The **ranine vein** is recognizable through the mucous membrane in the living subject.

The mucous membrane should now be dissected from the under surface of the free part of the tongue, beginning at the point of reflection of the membrane from the floor of the mouth, to expose the **ranine artery** and **vein,** the **branches of the lingual nerve** (p. 414) and the **mucous glands** (Blandin or Nuhn) near the tip.

The mucous membrane may also be raised from the floor of the sublingual space to expose the **sublingual glands,** a probe being first placed in the submaxillary duct of one side to define it.

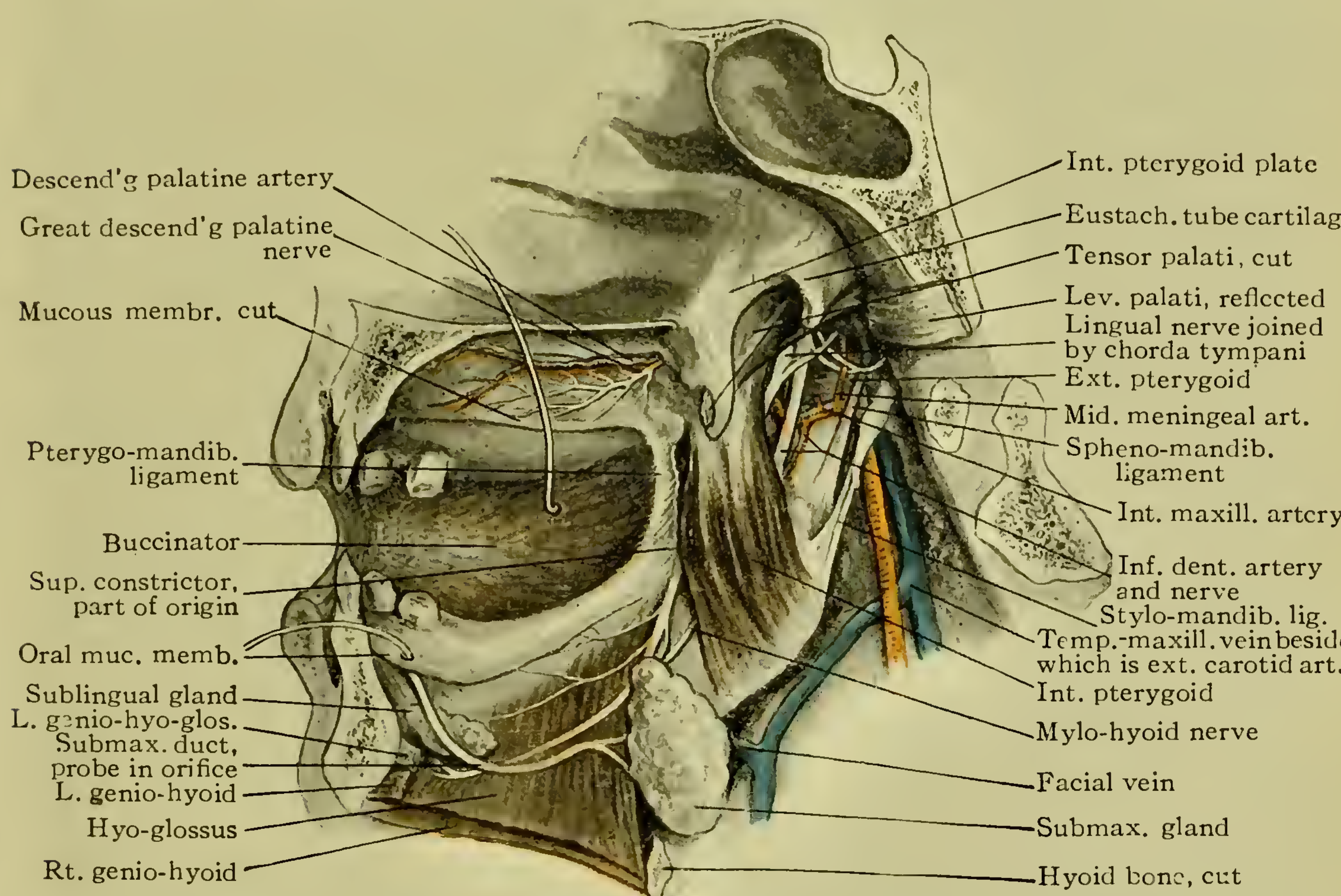

FIG. 217.—Mesial sagittal section showing oral cavity and related structures. The tongue and soft palate have been removed. The upper probe passes into the parotid duct. The middle meningeal artery is seen between the two roots of the auriculo-temporal nerve.

The body of the mandible of one side, preferably the left, may now be removed, cutting the soft structures attached to it close to the bone.

THE TONGUE.—The tongue is made up chiefly of muscular tissue, the dorsum and sides of the attached portion and all of the free portion being covered with mucous membrane.

The **dorsal surface** is divided into a *posterior* or *pharyngeal segment* and an *anterior oral portion* by the V-shaped *sulcus terminalis* which indicates the line of union between the tuberculum impar and the part derived from the paired embryonic pharyngeal segments. This posterior third of the dorsal surface is to be noted as being rough, owing to

the presence of **lymph-nodules** with which are intermingled **mucous glands.** The lymph-nodules constitute the **lingual tonsil,** a part of the *lymphoid ring of Waldeyer.*

Inflammation of the lingual tonsil is attended with great discomfort and sometimes with sufficient swelling to interfere with deglutition and respiration.

On the anterior two thirds of the dorsal surface, the *foramen cæcum,* the *circumvallate,* the *filiform* and the *fungiform papillæ* should be studied with the aid of a hand-lens and preferably in the living subject.

The **reflections of the mucous membrane** should now be followed. Behind, the **glosso-epiglottidian fold** or **frenum** is seen as a vertical median ridge passing from the dorsum to the lingual or anterior surface of the epiglottis (Fig. 222). From the sides of the posterior third the mucous membrane is reflected to the lateral walls of the pharynx and to the anterior palatine arch. In front of the latter, after forming a fold, the **papilla foliata,** it passes to the floor of the mouth. Under the free part of the tongue as already seen (p. 464) it forms the **frenum** and on the outer side of this, the **plica fimbriata.**

The **extrinsic muscles of the tongue,** the stylo-glossus, the palato-glossus, the hyo-glossus and the genio-glossus, should now be examined. The mucous membrane should be dissected from the line along which it was cut in removing the half of the mandible and the mylo-hyoid muscle of the same side should be removed, fully exposing the hyo-glossus with the related nerves and vessels (p. 374). Note the **stylo-glossus muscle,** arising from the styloid process and passing into the tongue superficially to the entrance of the hyo-glossus (Figs. 185 and 197).

The **genio-hyo-glossus** or **genio-glossus,** since its attachment to the hyoid bone is uncertain, is seen partly beneath the hyo-glossus, as a fan-shaped vertical sheet next the mesial plane. Its *origin* is the superior genial tubercle of the mandible, from which point its fibres pass backward and some of them upward and forward to blend with the muscular substance of the tongue, a few fibres being described as passing to the hyoid bone (Fig. 215).

The **palato-glossus** should be traced into the tongue from its *origin* in the aponeurosis of the soft palate.

The **genio-hyoid muscle,** though not belonging to the tongue, may be conveniently examined now. Its **origin** is the inferior genial tubercle of the mandible; its **insertion,** the body of the hyoid bone. It forms a rounded bundle below the border of the genio-glossus and close to the mesial plane. It is an elevator of the hyoid bone or a depressor of the mandible according to which of the bones is fixed at the moment of its **action** and is supplied by the hypoglossal nerve (Fig. 215).

The tongue, by its root, is thus seen to be attached to the styloid process, to the hyoid bone and to the genial tubercles of the mandible.

The **intrinsic muscles** are the **lingualis,** consisting of the *upper* and *lower* fibres, the **transversus** and the **perpendicularis.**

The **blood-supply** of the tongue is chiefly from the lingual artery, but also from the facial and ascending pharyngeal. The **veins** drain into the internal jugular and the **lymphatics** into the submaxillary and deep cervical nodes.

The **nerve-supply:** the **motor nerve** for both the extrinsic and intrinsic muscles is the hypoglossal (p. 379), with possibly some motor fibres from the facial through the chorda tympani; **common sensation** is supplied by the lingual branch of the fifth for the *anterior two thirds* and the glosso-pharyngeal for the *posterior third;* **special sense** is furnished by the glosso-pharyngeal for the *circumvallate papillæ* and by the chorda tympani by way of the lingual for the *filiform* and *fungiform papillæ.*

The **lingual nerve** should be exposed as it crosses the body of the mandible below the last molar tooth by incising the mucous membrane here (Fig. 217). It was traced to this point through the pterygo-maxillary region (p. 408); its course from this point has also been traced (p. 373). The **lingual branches of the glosso-pharyngeal** (p. 379) should be traced from beneath the outer border of the hyo-glossus to their terminations.

The lingual branch of the fifth may be exposed by the incision below the last molar tooth either for *stretching* or *resection.*

The tongue by reason of its muscular elements is an organ of mastication, deglutition and articulation, while its mucous membrane is an organ of special sense.

Macroglossia is a congenital lymphangioma of the tongue. The tongue is often the seat of **carcinoma,** for which its *excision* is practised. **Unilateral atrophy** of the tongue has occurred from pressure upon, or other form of injury to, the hypoglossal nerve.

THE NASAL FOSSÆ.

The **anterior nares** are to be noted as looking downward and as being below the level of the floor of the nasal chamber. They open into the **vestibule** or that part of the cavity which is surrounded by the lower lateral cartilage and which is lined with skin bearing the **vibrissæ** or stiff hairs.

The **posterior nares or choanæ** open into the naso-pharynx. Looking at the dissection from behind, the posterior nares are seen to be separated from each other by the posterior border of the nasal septum, to be bounded *above* by the body of the sphenoid, *below* by the hard palate and *externally* by the vertical plate of the palate bone and the internal pterygoid plate of the sphenoid. Note also in this view the transverse narrowness of the upper part of the cavities as compared with their width below, and their partial subdivision by the inwardly projecting turbinals or conchæ. The examination of the posterior nares in life is effected by posterior rhinoscopy and by digital exploration.

A sagittal section of the facial part of the skull is now to be made just far enough from the mesial plane to miss the nasal septum. As the septum is usually deflected to one or the other side, its position is to be ascertained by passing a probe or grooved director through the anterior naris, the section being made on that side away from which the septum deviates. The section through the cartilaginous part of the nose may be made first with a knife passed into the nose and made to cut upward.

THE NASAL SEPTUM.—The distinction between the **cartilaginous** and the **bony parts** of the septum may be made out through the mucous membrane, but will be seen more clearly upon removal of the latter.

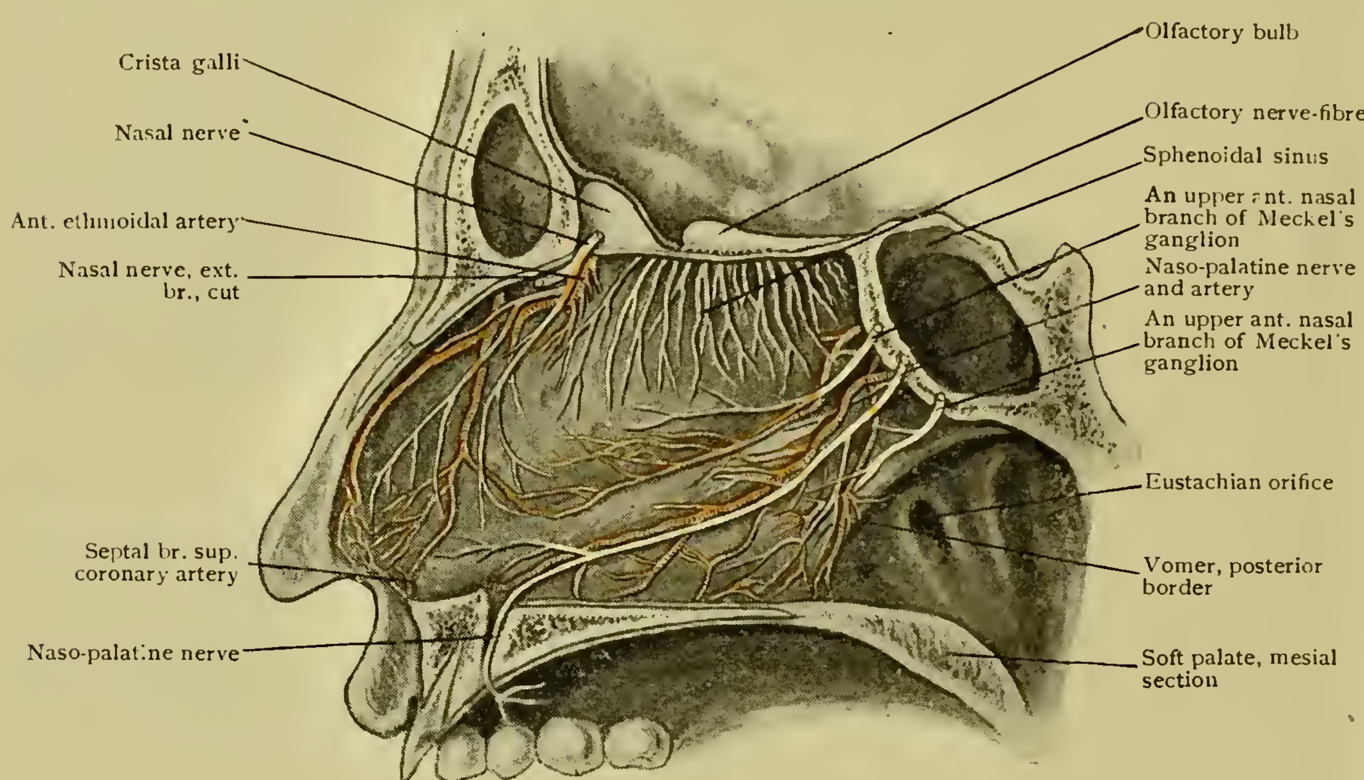

FIG. 218.—Left surface of nasal septum showing arteries and nerves, to expose which the mucous membrane has been partly removed.

The slight depression at the front part of the septum covered with skin and bearing hairs is the inner wall of the vestibule.

The **nerves** and **vessels** of the septum are between the bone and periosteum and the cartilage and perichondrium respectively. If the arteries are well injected their situation is usually easily recognized and they serve as guides to the nerves, since each of the principal nerves is accompanied by an artery.

The **inner set of olfactory nerve-fibres,** distributed to about the upper fourth of the septum, are very difficult to discover. Their dissection requires extreme care and patience, the use of a hand-lens being practically essential. The arrangement of the fibres is that of a plexiform network, some part of which will be recognizable upon scraping off the epithelium of the mucosa.

The **naso-palatine nerve,** a branch of Meckel's ganglion (p. 433), enters the nasal fossa through the spheno-palatine foramen with the spheno-palatine artery and passes across the back part of the roof of the cavity to reach the septum. Both the nerve and the artery having been cut in making the sagittal section, their distal ends may be picked up and traced to the septum and followed in their downward and forward course to the floor of the nasal fossa, the mucous membrane and periosteum being cut and reflected as the nerve and artery are traced. If the nerve cannot be found and dissected in this manner, the method outlined below may be employed. The naso-palatine nerve upon reaching the floor of the nasal fossa escapes from it through the foramen of Scarpa—the left nerve through the anterior and the right through the posterior foramen—to reach the mouth cavity, where it *terminates* in branches to the mucous membrane, the nerves of the two sides first forming a *plexus* (Fig. 219). It gives branches to the septum in its course.

The **spheno-palatine artery,** a branch of the internal maxillary artery (p. 418), enters the nasal fossa through the spheno-palatine foramen with the naso-palatine nerve and divides into an *external branch* for the outer wall of the nasal cavity and an *internal branch*, the *naso-palatine*, for the septal wall (Fig. 218). It accompanies the naso-palatine nerve, as seen above, as far as the foramen of Scarpa, and *terminates* in the lower anterior part of the nasal fossa, anastomosing with branches of the descending palatine artery, which latter ascends through the foramen of Stensen.

The **internal** or **septal branch of the nasal nerve** (Fig. 218) descends upon the front part of the septum in company with a branch of the anterior ethmoidal artery (p. 427).

The **septal branch of the superior coronary artery** ramifies on the lower part of the septum and some **branches of the posterior ethmoidal** at its upper back part.

The **component parts of the septum** are now to be exposed by completely removing the mucous membrane and the periosteum, when the septum will be seen to consist chiefly of the mesethmoid, the vomer and the triangular septal cartilage. These are supplemented above by the crests of the nasal bones, the nasal spine of the frontal and the crest and rostrum of the sphenoid; below, by the lower lateral cartilage and the crests of the palate processes of the superior maxillary and palate bones.

A small aperture may be found at the front part of the lower border of the septal cartilage, really in the small vomerine cartilage found here, which leads into the space enclosed by the two vomerine cartilages, the space and the cartilage being the rudiment of the **organ of Jacobson** of osmatic mammals.

Excessive deflection of the septum nasi, often due to untreated fractures, frequently causes obstruction of the nasal fossa into which it projects, necessitating *resection.*

If the dissector has been successful in the dissection of the nerves and vessels, the septum is now to be removed by dividing it above and below with stout scissors; if not, the bone should be cautiously cracked and the pieces carefully picked away from the mucous membrane and periosteum of the opposite side, leaving these membranes intact, with a view to the demonstration of the nerves and vessels of that side. If this is done, the septal mucous membrane should be cut away with scissors after completing the nerves and vessels, to expose the lateral wall of the nasal fossæ, preserving, however, the naso-palatine nerve and artery.

The Roof of the Nasal Fossa.—The roof should be examined, and its extreme narrowness noted as well as the structures that form it. Thus, the *posterior sloping portion* is formed by the body of the sphenoid and the alæ of the vomer, aided slightly by the sphenoidal process of the palate bone; the *middle horizontal portion* is the cribriform plate of the ethmoid; the *anterior sloping part*, the nasal spine of the frontal, the nasal bone and the upper and lower lateral cartilages.

As pointed out elsewhere (p. 332) the nasal roof thus comes into relation with both the anterior and middle fossæ of the skull. The cribriform plate may be *penetrated* and the brain wounded by a sharp instrument or foreign body passing upward through the nasal fossa. *Septic conditions* of the nasal fossæ may implicate the meninges of the brain, the avenues of transmission being the foramina of the cribriform plate. Through this plate also a *meningocele* may protrude.

The **floor of the nasal fossæ** is constituted by the hard palate, made up of the palatal processes of the superior maxillary and palate bones (p. 463).

The Lateral Wall of the Nasal Fossa.—Note as the most conspicuous features of the lateral wall, the **superior, middle** and **inferior turbinates** or **conchæ** and the manner in which they sub-divide the space into the **meati,** or antero-posterior recesses along this wall (Fig. 215). The **spheno-ethmoidal recess,** which receives behind the opening of the sphenoidal sinuses (Fig. 219), is seen above the superior turbinate.

The **superior meatus,** below the superior turbinate, appears as a small fissure; the **middle meatus,** below the middle turbinate, is longer and deeper and curves upward in front; the **inferior meatus,** below the inferior turbinate, is longest and is bounded below by the hard palate.

The smooth area of the middle meatus is the outer wall of the atrium and is bounded above and in front by a ridge, the **agger nasi.** The relation of the atrium to the middle meatus explains the fact that an instrument introduced through the anterior naris more readily and naturally passes into the middle than into the inferior meatus.

The **nasal mucous membrane,** it should be observed, presents somewhat different characters in different regions, as the yellowish tint in the fresh state of the **regio olfactoria**—the region of distribution of the olfactory nerves on the superior turbinate—and the rosy hue of the **regio respiratoria.** Moreover, the mucosa presents certain special features in certain localities, as upon the inferior and middle turbinates, where it is thick and spongy and contains cavernous or erectile tissue.

The cavernous or erectile tissue of the inferior turbinate is prone to become permanently thickened when repeatedly the subject of acute inflammation (rhinitis) and to cause more or less *obstruction.* The mucosa of the middle turbinate seems to be a favorite site for the *mucous polyp.*

The Nerves and Vessels of the Outer Wall.—The **outer group of olfactory nerves** (Fig. 215) are found upon the superior turbinate, not extending, however, either to its lower or its posterior border, according to Brunn. According to Cunningham, they extend to the upper part of the middle turbinate. The writer also has traced them to the upper fore part of the middle turbinate and over the entire mesial surface of the superior turbinate.

The **nasal nerve** (p. 423) accompanied by a branch of the anterior ethmoidal artery is usually easily detected at its entrance into the cavity through the nasal slit (Fig. 215); its *internal branch* has been traced (p. 469); its *external branch,* distributing filaments as it goes, passes downward and backward and escapes from the nasal cavity between the lower border of the nasal bone and the upper lateral cartilage to terminate as previously seen (p. 394).

The small **nasal branch** of the anterior superior dental nerve (Fig. 192) may be found at the lower fore part of the lateral wall.

The **posterior superior nasal branches of Meckel's ganglion** (p. 433) enter the nasal fossa through the spheno-palatine foramen. To discover them, the foramen is to be located by tracing proximally the previously isolated naso-palatine nerve or by "feeling" for the aperture by gently prodding the mucosa in its known position with a blunt instrument, comparing at the same time its situation in a denuded skull. Having determined the approximate location, incise the mucous membrane and follow the nerves, which are variable in size, over the upper and middle turbinates (Fig. 215); some *twigs* are sent to the septum.

The **maxillary antrum,** upon careful examination, will be seen to be related *above* to the floor of the orbit and the infraorbital canal, *behind* to the zygomatic fossa, *below* to the alveolar process and fangs of the teeth, *externally* to the facial surface of the maxilla and *internally* to the nasal fossa. Note in the dry preparation that its large orifice is constricted by the maxillary process of the inferior turbinate, the vertical plate of the palate bone, the lachrymal bone and the lateral mass of the ethmoid.

The situation of its orifice and the relation of the latter to its floor render the antrum liable to inflection in case of purulent discharge from the frontal or anterior ethmoidal cells and favor the retention of purulent matter within it. Dentigerous cysts are sometimes to be found here and tumors of various sorts, the latter encroaching upon any one or all of the cavities with which the antrum is related.

The **frontal sinuses** (Fig. 219) vary considerably in size and arrangement, the *septum sinuum frontalium* being often displaced to one or other side.

The **ethmoidal cells,** described as consisting typically of *anterior, middle* and *posterior* sets, present numerous variations in arrangement.

It is to be borne in mind that the maxillary antrum, the frontal sinuses, the ethmoidal cells and the sphenoidal sinuses are accessory parts of the nasal fossa and are lined with mucous membrane.

The **posterior inferior nasal branches of the great descending palatine nerve** leave that nerve as it passes through the posterior palatine canal (Fig. 219) and perforating the vertical plate of the palate bone, one above the posterior end of the middle turbinate and one farther down, pass over the middle and inferior turbinates (Fig. 215) and send *branches* to the middle and inferior meati.

The **superior meatus** should now be exposed by cutting away with scissors a part of the superior turbinate (Fig. 219). This should bring to view the *orifice of the posterior ethmoidal cells.* This meatus may be a double fissure owing to the presence of two superior turbinates.

The **middle meatus** is to be displayed by cutting away the greater part of the middle turbinate (Fig. 219). On the lateral wall of the meatus note a bulging, the **ethmoidal bulla,** and behind this the *orifice of the middle ethmoidal cells.* In front of the bulla is a crescentic fissure, the **hiatus semilunaris,** the anterior prominent margin of which is the uncinate process of the ethmoid articulating with the ethmoidal process of the inferior turbinate. The hiatus leads into a deep groove, the **infundibulum.** With a small probe, or piece of flexible wire passed into the frontal sinus and directed downward (Fig. 219), demonstrate the *opening of the frontal sinus* into the infundibulum. The *anterior ethmoidal cells* also open here either by a separate orifice or in common with that of the frontal sinus. In close proximity is found also the *orifice of the maxillary sinus* or *antrum of Highmore* (Fig. 219). Introduce a probe into this and note the continuity of its mucous membrane with that of the nasal cavity. The evident purpose of these spaces is to reduce the weight of the bones of the face without diminishing their bulk, and to serve as resonating cavities. They thus become important adjuncts to the vocal apparatus. The so-called nasal voice is the voice that is not nasal, *i.e.*, it is flat and "nasal" because, being projected through the mouth instead of through the nose, the resonant quality is absent.

The accessory nasal sinuses are of sociologic importance, since without them there could be no such thing as vocal music or effective oratory. Their clinical importance is great: their continuity with the nasal cavity causes them to participate in the inflammations (coryza, rhinitis) of that cavity and their unyielding bony walls and small and easily obstructed outlets subject their membranous lining and its contained nerve-filaments to pressure. This pressure produces discomfort, varying from a sense of uncomfortable fulness in a slight "cold in the head" to agonizing pain in the more severe forms of sinus disease. The pain in such cases is reflected to the areas of distribution of some one or more of the branches of the ophthalmic and maxillary nerves. Thus, in frontal sinus trouble and less markedly in ethmoidal, there will be supraorbital, ocular and temporal neuralgia. In blocking of the sphenoidal sinus, pain is referred to the mastoid region.

The **inferior meatus** should now be more fully exposed by cutting away the anterior third or more of the projecting scroll of the inferior turbinate. The orifice of the **ductus ad nasem** which conveys the lachrymal secretion into the inferior meatus from the conjunctival culs-de-sac should be located and a probe should be passed into it, the flap-like **valve of Hasner** being noted (p. 388).

The **bones composing the outer wall of the nasal fossa** are chiefly the body of the superior maxilla and the lateral mass of the ethmoid, supplemented *in front* by the nasal process of the maxilla, the nasal and the lachrymal bones; *below* by the inferior turbinate; *behind* by the vertical plate of the palate bone and the internal pterygoid plate of the sphenoid.

The nose is then an organ of special sense, an important part of the system of air passages of the respiratory apparatus and an adjunct to the vocal mechanism.

The **blood=supply** of the nasal chambers is derived from the spheno-palatine and the anterior and posterior ethmoidal arteries for the *outer wall*; the *supply of the septum* has been indicated (p. 469). The veins correspond in the main with the arteries.

The **nerve=supply** for the outer wall is from the nasal, the upper posterior nasal branches of Meckel's ganglion, the lower posterior nasal branches of the great descending palatine nerve and the olfactory. The septal nerves have been indicated (p. 469).

Hemorrhage from the nose, epistaxis, is frequently from the vessels of the fore part of the septum and in such case is sometimes controllable by compression of the entire thickness of the upper lip (septal branch of superior coronary); if from the back part of the septum or of the lateral wall (spheno-palatine artery) plugging of the posterior nares may be necessary in severe cases.

The pharyngeal tonsil (p. 461), being situated in the fore part of the naso-pharynx, has important clinical relations to the nasal fossæ, since the very common overgrowth of its lymphoid elements, *adenoids*, is of importance chiefly by reason of the nasal obstruction it produces, this obstruction inducing mouth-breathing with all its attendant ills and interfering with the normal development of the facial bones. This structure also increases the susceptibility of the naso-pharynx to disease and tends to bring about chronicity of such disease. The continuity of the naso-

pharyngeal mucous membrane with that of the Eustachian tube and the middle ear renders the extension of inflammation from the former to the latter easy; it follows that in the majority of instances, middle ear disease results from naso-pharyngeal troubles.

The asserted **relationship between the nasal mucosa and the sexual apparatus** is difficult to explain except upon comparative anatomical grounds. The occurrence of vicarious menstruation in the form of epistaxis is not necessarily an instance of such relationship, since vicarious menstruation occurs with equal frequency from the gastric and intestinal mucosa and from that of the bladder. The high degree of development of the olfactory apparatus in the macrosmata is suggestive. In these animals the olfactory sense is not only important to the life of the individual, since the animal depends largely upon this sense to discover his prey and to avoid his

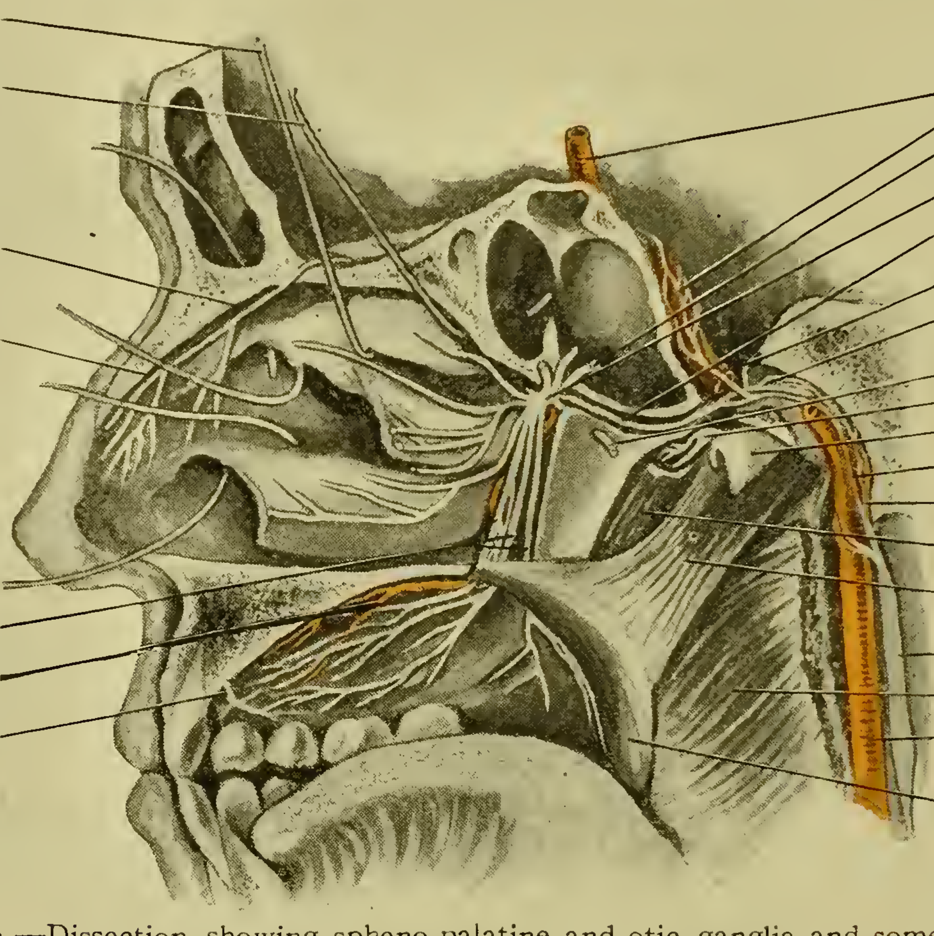

FIG. 219.—Dissection showing spheno-palatine and otic ganglia and some of their branches. The lateral wall of the nasal fossa has been broken through to show the descending palatine nerves and the anterior parts of the middle and inferior turbinals removed. The Vidian nerve has been exposed by breaking through the base of the pterygoid process.

enemies, but it is of moment to the life of the race, *i.e.*, to the begetting of offspring, since it is through the medium of the sense of smell that he seeks out his mate and that his sexual appetite is aroused.

The **descending** and the **posterior branches of the spheno-palatine ganglion** may now be dissected.

The **descending branches,** the **great,** the **small** and the **accessory posterior palatine nerves,** are to be exposed as they pass downward from the spheno-maxillary fossa, the *large nerve* through the posterior palatine canal, and the two *smaller nerves* through the accessory canals, by breaking through the vertical plate of the palate bone (Fig. 219). This may be done with a Hey's saw or a chisel, the position of the posterior palatine foramen, just in front of the posterior border of the hard

palate, serving as a guide. The posterior inferior nasal branches of the large or anterior nerve, already dissected (p. 472), also serve as guides and should be preserved. Tracing the **great** or **anterior nerve** in company with the **descending palatine artery** through the foramen to the under surface of the hard palate, it should be followed forward and its branches noted (Fig. 219).

The **small** and the **accessory nerve** should be followed as far as possible toward their *distribution* upon the uvula, tonsil, and gums, the

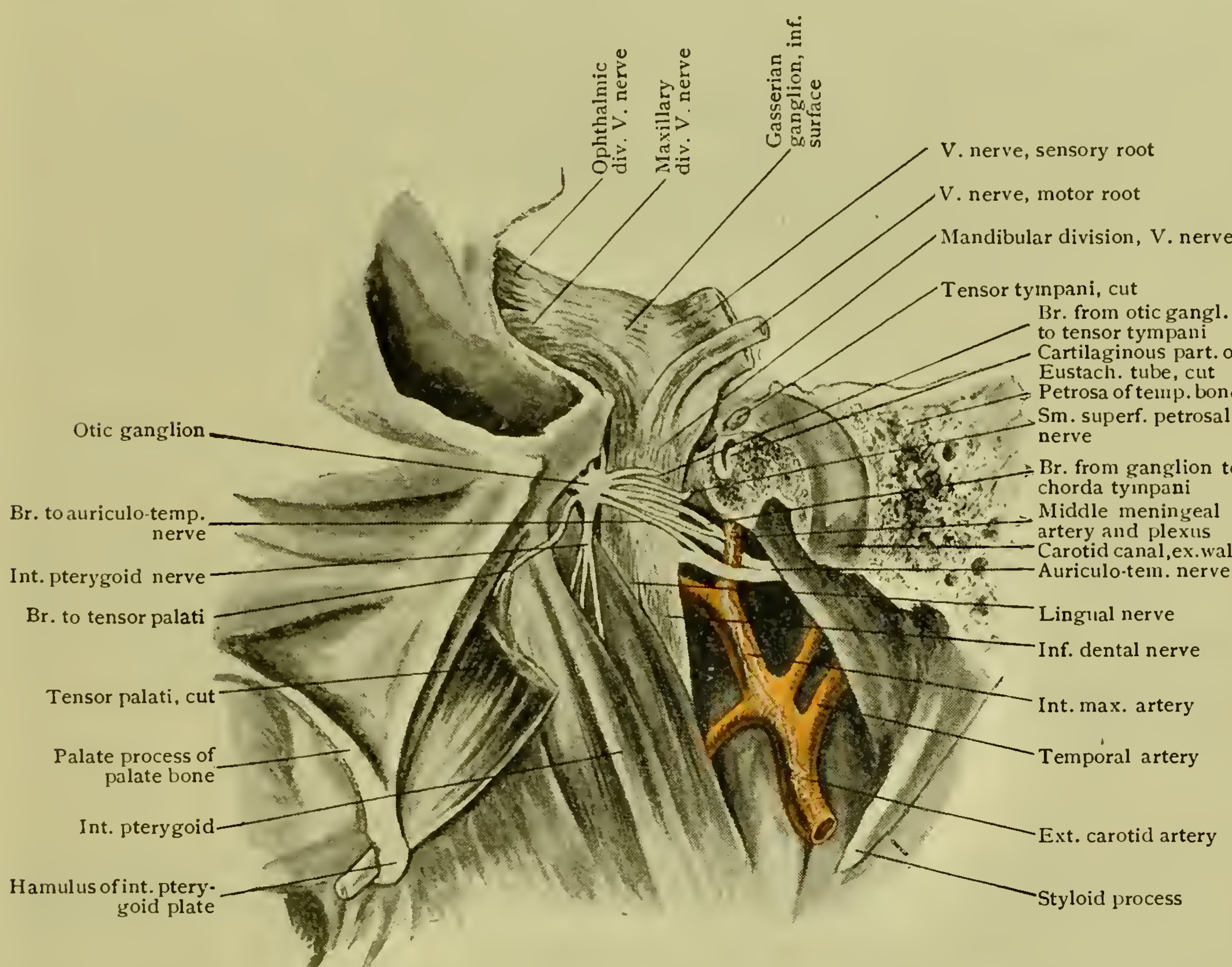

FIG. 220.—Otic ganglion and branches seen from mesial aspect, section of skull being not sagittal but approaching plane of long axis of petrosa. Compare Figs. 219 and 196.

small posterior nerve giving *motor branches* to the levator palati and azygos uvulæ.

The **descending palatine artery** (p. 418) passes downward through the posterior palatine canal to reach the under surface of the hard palate. Passing forward it enters the nasal cavity through the foramen of Stensen to anastomose with the naso-palatine artery.

The bone section just made may be extended upward so as to expose Meckel's ganglion (Fig. 219).

The **pharyngeal** or **pterygo-palatine nerve,** the posterior branch of Meckel's ganglion (p. 433), may be discovered before its entrance into

and after its exit from the pterygo-palatine canal (Fig. 219); it supplies the mucous membrane near the fossa of Rosenmüller. It is accompanied by the **pterygo-palatine artery** (a. palatina major) from the internal maxillary.

The **Vidian nerve** (p. 433) may be traced into the Vidian canal and may be exposed by breaking into this canal (Fig. 219); this will also expose the **Vidian artery** from the internal maxillary.

Now reflect the mucous membrane from the internal pterygoid plate and carry the dissection backward, exposing first the tensor palati muscle and then the levator palati and the superior constrictor and the cartilage of the Eustachian tube (Fig. 219).

The **tensor palati** (m. tensor veli palatini) (Fig. 219) **arises** from the scaphoid fossa, the spine of the sphenoid and the outer surface of the Eustachian cartilage; passing downward on the outer side of the internal pterygoid plate, its tendon turns round the hamulus (Fig. 217) and passes to its insertion in the palatal aponeurosis. Its **nerve-supply** is a branch from the otic ganglion (Fig. 220); its **action** is to make the soft palate tense.

The **otic ganglion** (p. 416) may be exposed by cutting away the upper part of the tensor palati and the anterior end of the Eustachian cartilage (Fig. 220).

The **levator palati** (m. levator veli palatini) (Fig. 219) **arises** from the under surface of the apex of the petrous bone and the Eustachian cartilage and is **inserted** into the aponeurosis of the soft palate. Its **nerve-supply** is a branch from the pharyngeal plexus; its **action** is to elevate the soft palate.

THE LARYNX.

The anterior and lateral aspects of the larynx have been dissected (p. 363). These may be briefly reviewed and the connections between the upper border of the thyroid cartilage and the hyoid through the medium of the thyro-hyoid membrane (p. 363) and the lateral thyro-hyoid ligaments should be made out. Note that when the larynx moves upward, its upper extremity enters the space enclosed by the hyoid bone, the thyro-hyoid membrane being attached to the upper border of the deep surface of the bone.

The larynx, the laryngo-pharynx, the hyoid bone and the tongue should be removed together from the facial part of the skull by cutting the attachments of the tongue to the mandible and dividing the walls of the pharynx a little above the level of the larynx.

THE CARTILAGES OF THE LARYNX.—Before dissecting the larynx it will be well to note the *three unpaired cartilages*, the **thyroid,** the **cricoid** and the **epiglottis,** and the *three smaller pairs of cartilages*, the **arytenoids,** the **cornicula** and the **cuneiforms,** which constitute

its *framework*, examining the denuded and isolated cartilages if they are available.

Note the form of the **thyroid cartilage** with its two wings or *alæ* forming an acute angle in front where they are continuous, and the upward and downward prolongation of the posterior borders of the alæ, as the *superior* and *inferior cornua.* Note the form of the **cricoid** or **ring cartilage** with its smaller anterior *arcus* and larger posterior quadrate portion, or *lamina*, as well as the leaf-like shape of the **epiglottis.**

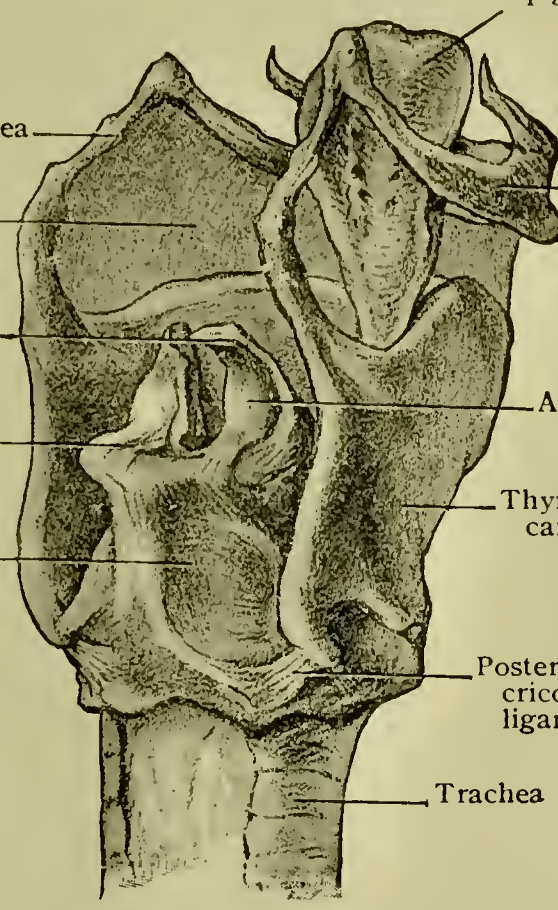

FIG. 221.—Cartilages of larynx united by their ligaments; right half of thyro-hyoid membrane has been removed; postero-lateral aspect.

The **arytenoid cartilages,** somewhat pitcher-shaped as their name implies, are three-sided pyramids, reposing by their bases on the upper surface of the lamina of the cricoid cartilage and articulated with it.

THE EXTERIOR OF THE LARYNX.—In the specimen, after removing the middle and inferior pharyngeal constrictors, note the connection of the superior cornua of the thyroid cartilage with the greater cornua of the hyoid bone by the lateral thyro-hyoid ligaments; the latter are the thickened posterior margins of the thyro-hyoid membrane which has already been examined (p. 363) and which connects the upper border of the alæ with the upper border of the hyoid bone, a **bursa** lying between the deep surface of the bone and the anterior surface of the membrane (Fig. 224).

Now examining the **crico=thyroid membrane,** first removing the crico-thyroid muscle (p. 363) of one side, note that the *central* thickened triangular portion of the membrane is attached by its base to the upper border of the anterior arch of the cricoid cartilage and by its blunt apex to the thyroid cartilage, while the *lateral* portions of the membrane, attached below to the cricoid cartilage, are not connected with the lower border of the thyroid but pass by it into the interior of the larynx, where, as will be seen later, their free median edges constitute the fibrous basis of the true vocal cords.

Examine now the articulation between the lower end of the inferior cornu of the thyroid cartilage and the articular facet on the side of the cricoid cartilage at the junction of its lamina and arcus. This is the **crico=thyroid articulation.** Note that its action is a movement around a transverse axis, a movement effected by the crico-thyroid muscle (p. 484). The dissector will now have demonstrated the connection between the thyroid and cricoid cartilages, as well as that between the thyroid cartilage and the hyoid bone.

Turning now to the posterior aspect of the larynx as seen in the preparation, one notes the posterior relation of the laryngo-pharynx, the upper aperture of the larynx and the epiglottis.

The **epiglottis** points almost directly upward. As seen in the undissected specimen the form of the cartilage is largely masked by the covering of soft tissues. On the *anterior* or *lingual surface*, note the median **glosso=epiglottidean fold** or **ligament** (p. 466) with the little depression or **vallecula** on either side and the two **lateral glosso=epiglottidean ligaments** or **pharyngo=epiglottidean folds** (Cunningham) by which the epiglottis is connected with the tongue. Its *posterior* or *laryngeal surface* is free, is covered with mucous membrane and presents the prominent tubercle or **cushion,** beneath the mucous membrane of which are many glands.

The **superior aperture of the larynx** (p. 462) is limited in front by the free posterior surface of the epiglottis and at the sides by the aryteno-epiglottidean folds, which pass from the lateral margins of the epiglottis and converge behind. The whitish swellings near the posterior extremities of these are the **cornicula laryngis** or **cartilages of Santorini,** one on either side, and in front of these, the **cuneiform cartilages** or **cartilages of Wrisberg** (Fig. 222).

The **sinus pyriformis** is the fossa limited on the mesial side by the aryteno-epiglottidean fold and on the outer side by the ala of the thyroid cartilage, the thyro-hyoid membrane and the great horn of the hyoid bone. It is a part of the pharynx.

The **recurrent laryngeal nerve** and the **inferior laryngeal artery** should now be picked up in the lateral interval between the trachea and œsophagus and traced upward to the outer aspect of the cricoid

cartilage; the *larger* of the *two branches* into which the nerve divides here should be traced to the point where it enters the larynx under the lower border of the thyroid cartilage; the *smaller posterior branch* should be traced upwards and backwards behind the crico-thyroid joint to the

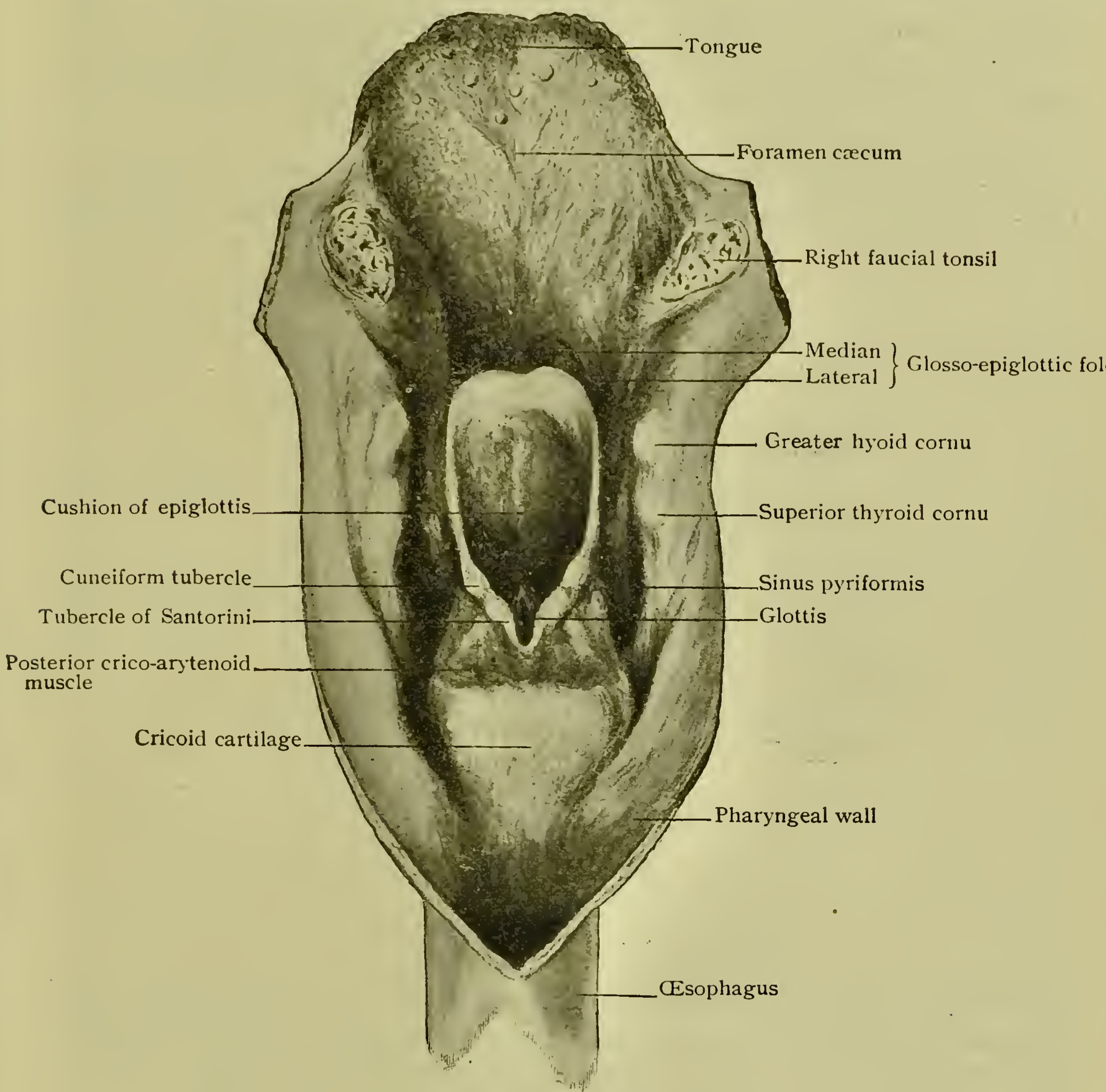

Fig. 222.—Pharynx opened from behind, showing superior laryngeal aperture and mucous pouches embraced by wings of thyroid cartilage; cricoid cartilage and muscles are covered with mucous membrane.

posterior aspect of the cricoid cartilage—any tissue that overlies it being cut away—to its disappearance under the posterior crico-arytenoid muscle. After the isolation of this muscle, which the nerve supplies, the latter may be traced to its termination in the arytenoideus muscle.

The anterior wall of the laryngo-pharynx should now be removed from the posterior aspect of the larynx by first carefully dissecting off

the mucous membrane from the latter, and noting the attachment to the median ridge of the cricoid of some muscular fibres of the œsophagus.

The **posterior crico=arytenoideus** muscles now exposed are seen to **arise** from the posterior surface of the cricoid cartilage (Fig. 223) and to pass upward and outward to be **inserted** in each case into the external angle or muscular process of the base of the arytenoid cartilage. These muscles, by pulling the muscular processes backward, rotate the arytenoid cartilages and cause the inner angles of their bases, the *vocal processes*, to move outward.

The **arytenoideus muscle** (Fig. 223) is to be exposed by removing the mucous membrane carefully from its surface, particular care being

FIG. 223.—Muscles of larynx from behind.

exercised to preserve the superficial *oblique portions* of the muscle which decussate, and which pass to and around the apices of the cartilage, and looking out for its nerve, mentioned above. The *deep* or *transverse part* of this muscle connects the posterior surfaces of the two arytenoid cartilages: the action of the latter is, therefore, to approximate these cartilages and with them the vocal cords.

The **aryteno=epiglottidean fold** of one side is now to be dissected by making an incision on the outer side of the fold close to its free margin and continuing the removal of the mucous membrane from the outer border of the arytenoid cartilage in an upward and forward direction. This must be done with extreme care to preserve the aryteno-epiglottideus muscle. Some branches of the internal laryngeal nerve

on their way to the interior of the larynx may be found beneath the mucous membrane of this fold, as well as some branches to the epiglottis.

The **aryteno-epiglottideus muscle*** as now exposed should be recognized as being the continuation of the oblique portion of the arytenoideus passing to the lateral margins of the epiglottis. Thus the arytenoideus and the aryteno-epiglottidei constitute a sort of sphincter for the superior laryngeal aperture.

The tongue and any other extraneous tissue in connection with the larynx except the hyoid bone should now be detached.

The Interior of The Larynx.—The **internal laryngeal nerve** and the **superior laryngeal artery** should be picked up at the outer surface of the thyro-hyoid membrane and the membrane should be freely incised by entering the point of a knife close to the nerve and artery; making slight traction on the latter they should be traced into the pyriform sinus, the anterior part of which they cross. In order to gain better access to this space the greater part of the ala of the thyroid must be removed. This is to be done by disarticulating its inferior cornu from the cricoid cartilage, dividing the thyro-hyoid ligament and membrane and cutting the ala vertically about one-third of an inch from its angle of junction with the other ala. In removing the cartilage, have regard for the **internal laryngeal nerve** and the **superior laryngeal artery,** which have been followed to the pyriform fossa, for the **anterior branch of the recurrent laryngeal nerve,** which has been traced to the lower border of the thyroid cartilage, and for the **inferior laryngeal artery**; their dissection should now be completed. The latter nerve breaks up into branches for the thyro-arytenoid, the lateral crico-arytenoid and the thyro-epiglottideus muscles.

Carefully removing the connective tissue, the muscles are exposed.

The **lateral crico-arytenoid muscle** (Fig. 224) **arises** from the upper border of the lateral part of the cricoid as far back as its superior articular facet and by a few fibres from the crico-thyroid membrane. It passes upward and backward to be **inserted** into the muscular process of the arytenoid. Its **action** is to draw the outer angle of the arytenoid forward and so to move the vocal cord inward.

The **thyro-arytenoid muscle** (Fig. 224) is often blended at its lower border with the preceding muscle. What is seen here is the *external portion* of the muscle which forms the outer wall of the laryngeal pouch or sinus, and which **arises** from the lower half of the inner surface of the thyroid cartilage near its angle and from the adjacent part of the crico-thyroid membrane; it is **inserted** into the muscular process and outer border of the arytenoid cartilage. The *inner portion,* not separable from the outer, is close to the outer side of the true vocal cord and forms a mass, triangular on cross section, which constitutes the floor of

*Aryepiglotticus.

the ventricle of the larynx. It **arises** from the angle between the alæ of the thyroid cartilage and is **inserted** into the vocal process and the adjacent antero-external surface of the arytenoid cartilage. The **action** of this muscle is to approximate the points of attachment of the vocal cords and hence to relax them, being antagonistic to the crico-thyroid muscle.

The **thyro=epiglottideus muscle** is merely the upper fibres of the thyro-arytenoid which curve upward and backward to the side of the epiglottis.

Looking through the superior aperture of the larynx one may see two small antero-posterior bands, one on each side; these are the **superior or false vocal cords** or bands. The part of the laryngeal cavity above their level is the **supraglottic portion** or **vestibule.**

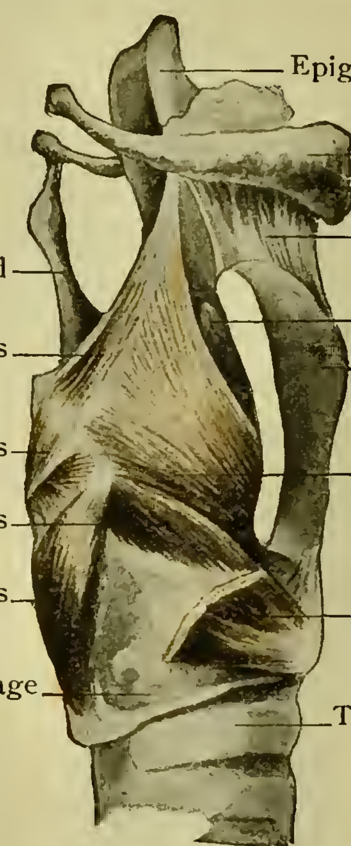

FIG. 224.—Muscles of larynx, lateral view after partial removal of right thyroid ala.

Looking between these bands, one sees a pair of similar but more prominent bands, the **inferior or true vocal cords,** the aperture between which is a part of the **glottis** or **rima glottidis.** The part of the laryngeal cavity between the level of the true cords and that of the superior cords is the **glottic region.** On each lateral wall of the glottic region, between the true and the false cord, is an antero-posterior fossa, the **ventricle** or **sinus** of the larynx. The space below the level of the true cords is the **infraglottic region.**

The **rima glottidis** or **chink of the glottis** includes the space between the true cords and that between the arytenoid cartilages, into which latter space the mucous membrane is prolonged. The **rima** or **glottis vocalis** is that part of the chink which is between the cords; the **rima respiratoria** is that part of it between the arytenoid cartilages.

The **lateral part of the crico=thyroid membrane** (p. 478) should now be displayed by removing the lateral crico-arytenoid muscle and also the thyro-arytenoid muscle except its internal fibres which are in relation with the true vocal cord; after noting the latter relation these internal fibres should also be removed. The lateral part of the crico-thyroid membrane is now seen to be attached in front to the lower half of the ala of the thyroid cartilage near its angle and behind to the vocal process of the arytenoid cartilage. Its inner free margin is called the **inferior thyro=arytenoid ligament** and is the fibrous element of the true vocal cord. The mucous membrane which covers it is very closely adherent.

If the mucous membrane and the subjacent areolar layer, the **elastic sheath of the larynx,** on the inner surface of the thyro-arytenoid muscle

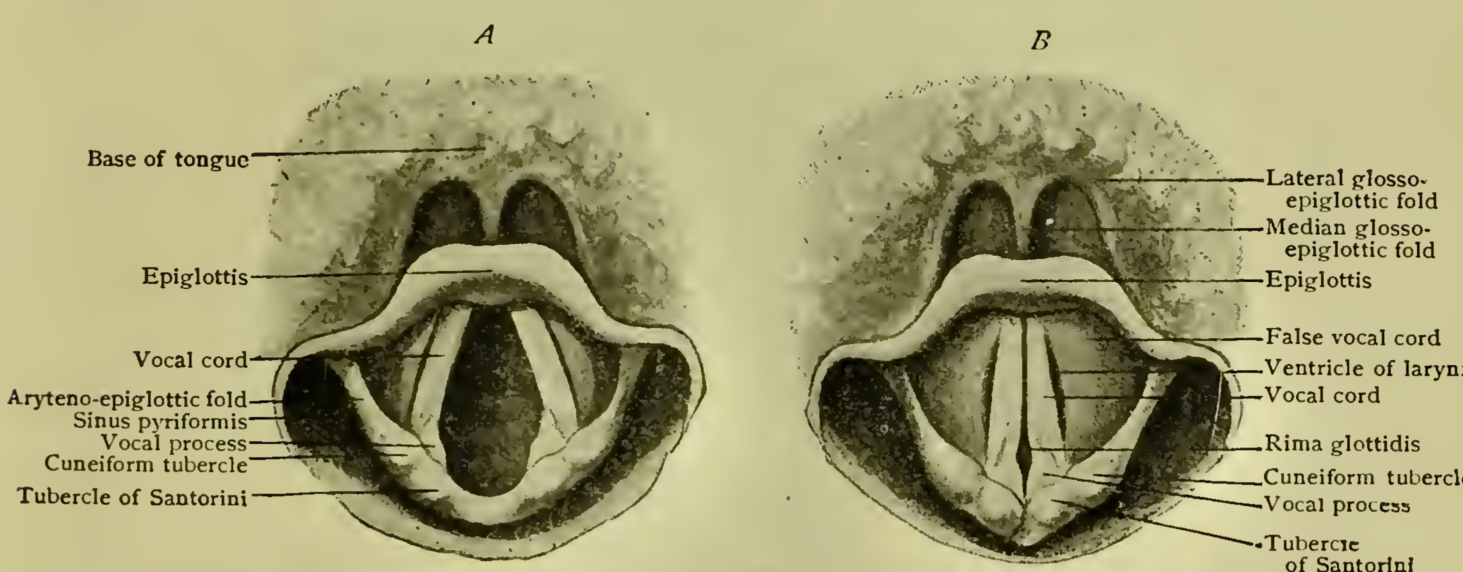

FIG. 225.—Interior of larynx as seen with laryngoscope. *A*, rima glottidis widely open; *B*, rima glottidis closed.

were not disturbed in removing that muscle, the dissector will now have reached the outer wall of the **laryngeal pouch** or **sacculus laryngis** and the outer wall and floor of the **ventricle of the larynx.** Cutting through this membrane at the level of the true cord, the ventricle is opened from the outer side and the pouch may be explored.

The **superior** or **false vocal cord** may be dissected to discover, if possible, the weak and variable **superior thyro=arytenoid ligament,** a localized thickening of the elastic sheath of the larynx.

The remains of the lateral wall just dissected may now be completely removed to afford a view of the laryngeal surface of the opposite wall and a better opportunity to study the ventricle and the sacculus laryngis.

The **joints and ligaments of the larynx** and its **cartilages** may be studied after the removal of the muscles. The anterior surface of the epiglottis should first be denuded, in the course of which procedure the **hyo=epiglottidean ligament,** passing from the petiole of the epiglottis to the hyoid bone, and the **thyro=epiglottidean ligament,** passing downward

from the same point, *i.e.*, the lower extremity of the epiglottis, to the upper part of the angle between the alæ of the thyroid cartilage, should be dissected.

The **crico=arytenoid joints** with their *capsular ligaments* and their *articular surfaces* should be examined. The **crico=thyroid joints** have been examined (p. 478). The connection between the apices of the arytenoids and the cornicula laryngis or cartilages of Santorini, **synchondrosis arycorniculata,** is a synchondrosis; the perichondrium of the arytenoid is directly continuous with that of the corniculum. The **extrinsic ligaments,** those connecting the larynx with other parts, have been sufficiently indicated.

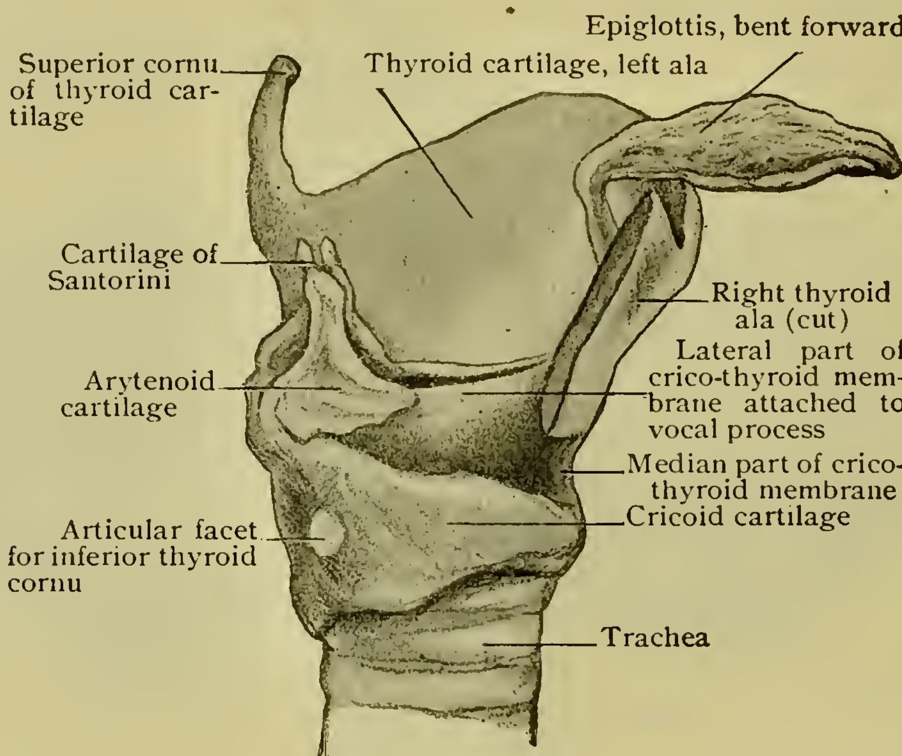

FIG. 226.—Lateral view of larynx after removal of greater part of right thyroid ala, showing attachment of crico-thyroid membrane to arytenoid cartilage. The free border of the membrane constitutes the thyro-arytenoid ligament and the framework of the vocal cord.

The **effect of the intrinsic muscles upon the tension and position of the vocal cords** has been pointed out in connection with each muscle, except the crico-thyroid. The **action of the crico=thyroid** is to make the vocal cords tense, thus antagonizing the thyro-arytenoid. It does this by pulling the front of the cricoid cartilage upward, thus depressing its posterior part, the lamina, the movement occurring about a transverse axis through the crico-thyroid joint, since the thyroid cartilage is fixed by the extrinsic muscles.

The **blood=supply** includes the superior laryngeal, the inferior laryngeal and the crico-thyroid *arteries*. The *veins* correspond in the main. The **lymphatics** pass to the posterior tracheal nodes and to those near the sterno-mastoid; the position of the former nodes doubtless explains the frequent absence of any discoverable glandular enlargement in laryngeal diphtheria.

The **nerve-supply** is the superior laryngeal of the vagus as the *sensory nerve*, but supplying motor fibres to one muscle, the crico-thyroid, through its external laryngeal branch (p. 380); and the recurrent laryngeal as the *motor nerve* but supplying a few sensory fibres to the mucosa.

Laryngeal complications in the form of edema of the glottis (see below) may follow *fracture of the hyoid bone*; the same observation applies to *fractures of the cricoid and thyroid cartilages* which sometimes occur, especially in later adult life when more or less ossification has taken place. *Laryngotomy* has been referred to

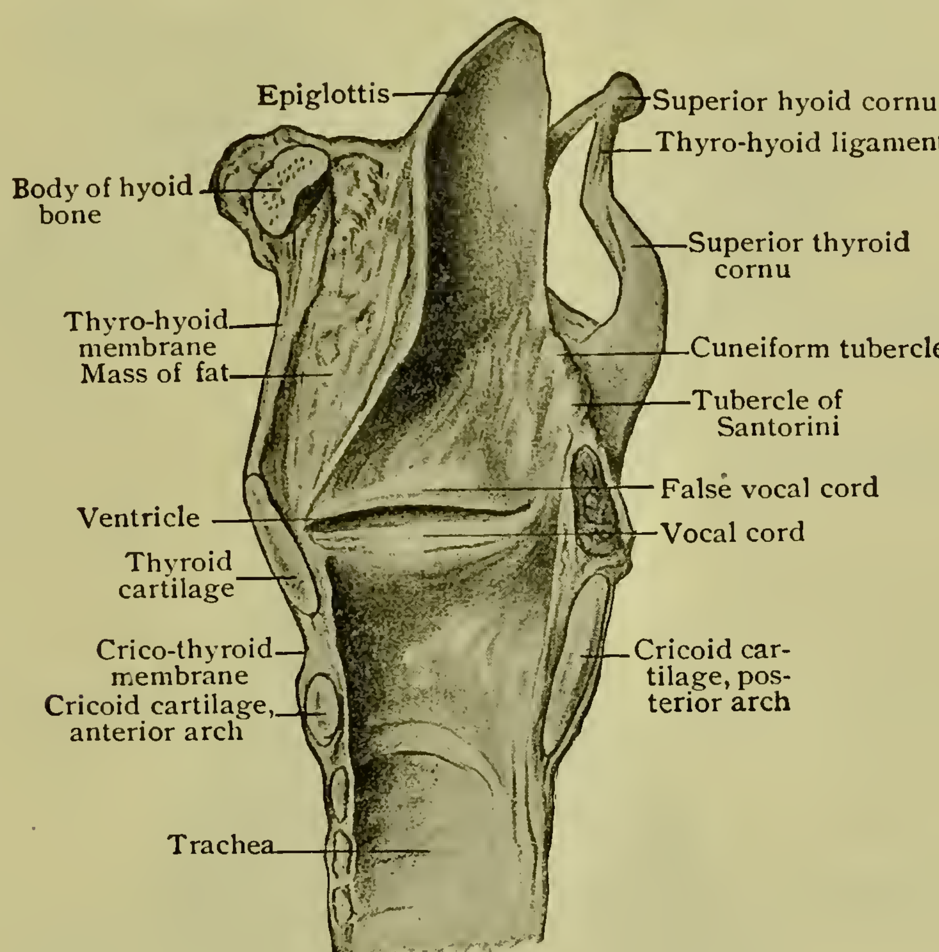

FIG. 227.—Median sagittal section of larynx; right side seen from within.

(p. 363). The relation of the mucosa to the cartilages, or rather the quantity and character of the sub-mucous tissue, are of great clinical importance. On the superior and inferior vocal cords, the mucosa is closely adherent, the submucous tissue being very scant, but elsewhere, and especially on the aryteno-epiglottidean folds, the looseness of this tissue is such that its infiltration with serum readily occurs, the swelling being so marked as to obstruct the ingress of air partially or completely. This grave condition is *edema of the glottis;* it may result from any severe irritation or inflammation.

Spasm of the laryngeal muscles, interfering with respiration, is caused by irritation of the nerves, as by pressure by a tumor or aneurism (p. 370); a greater degree of pressure causes *paralysis of the muscles.* The effects of such paralysis vary from hoarseness to complete aphonia and interference with breathing according to what muscles are affected and whether the paralysis is unilateral or bilateral.

THE PREVERTEBRAL MUSCLES.

The dissection of the deep prevertebral structures is now to be completed. For this purpose the cervical portion of the spine and, in addition, the first three thoracic vertebræ may be detached by severing the connections between the third and fourth thoracic vertebræ, the vertebral attachment of the first and second pairs of ribs being undisturbed.

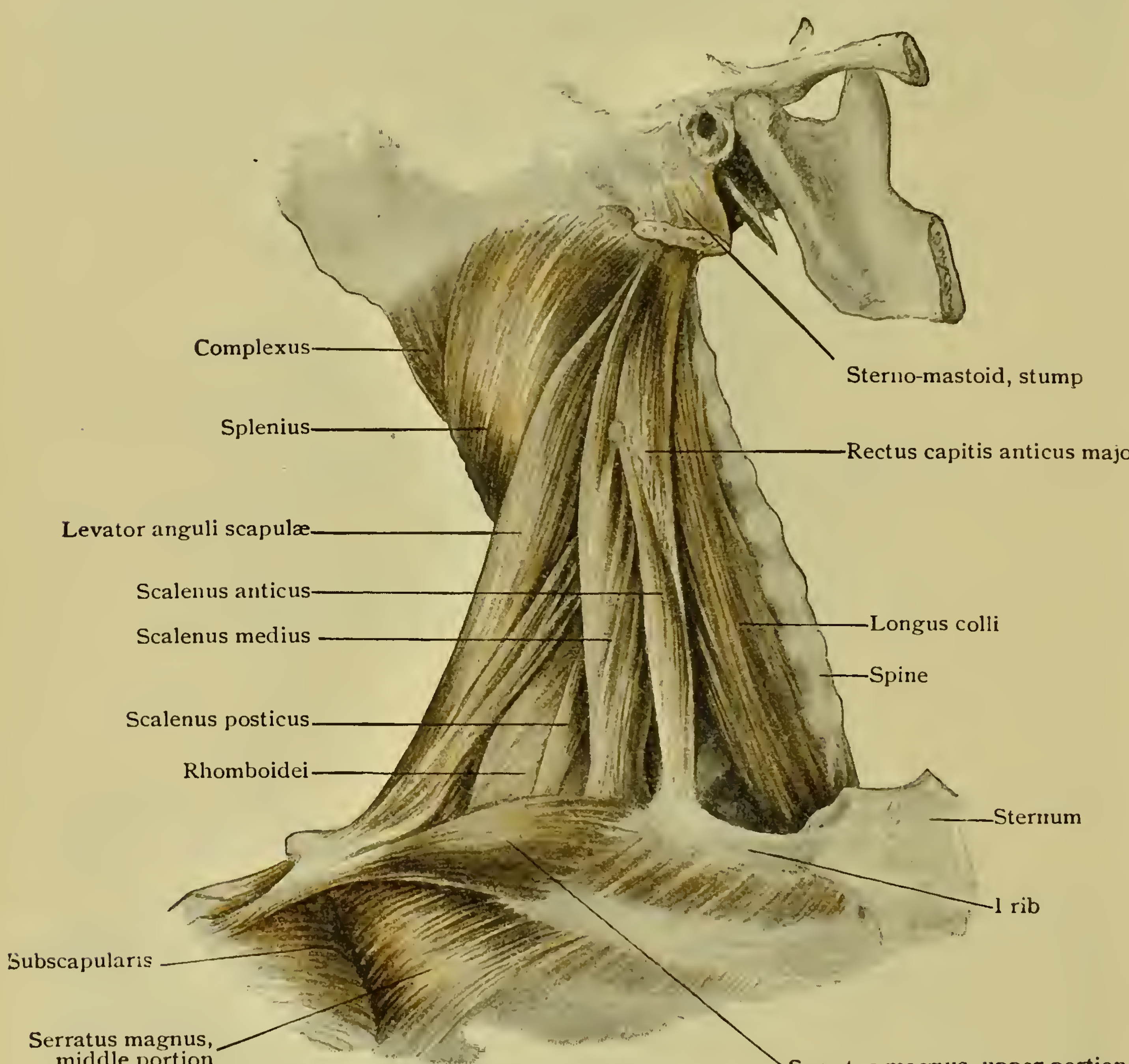

FIG. 228.—Dissection of right side of neck, showing scalene and adjacent muscles.

Any remnants of the prevertebral fascia should be removed and the surfaces of the muscles carefully cleaned.

LONGUS COLLI.—The *medial* or *vertical portion*: **Origin,** the bodies of the sixth and seventh cervical and first, second and third thoracic vertebræ; **insertion,** the bodies of the first, second, third and sometimes the fourth cervical vertebræ. The *inferior oblique portion* diverges below from the medial portion to be **attached** to the transverse processes

of the fifth and sixth cervical vertebræ. The *superior oblique portion*, from its **origin** on the third, fourth, fifth and sixth transverse processes, passes upward and inward to join the upper part of the medial portion. **Nerve-supply,** the second, third and fourth cervical nerves; **action,** forward and slight lateral flexion of the spine.

Rectus Capitis Anticus Major (Fig. 228).—**Origin,** the anterior tubercles of the transverse processes of the third, fourth, fifth and sixth cervical vertebræ; **insertion,** the under surface of the basilar process; **action,** flexion and rotation of the head; **nerve-supply,** the second, third and fourth cervical nerves.

After cleaning the muscle, separate it with the scalpel-handle from the underlying lesser anterior straight muscle and then cut it at its insertion and reflect it.

Rectus Capitis Anticus Minor.—**Origin,** the anterior surface of the lateral mass of the atlas; **insertion,** the under surface of the basilar process behind the preceding muscle; **action,** flexion of the head; **nerve-supply,** the first cervical nerve.

This muscle may be raised upon the blunt dissector from the underlying anterior atlanto-occipital ligament; it may be cut and removed after the lateral straight muscle has been dissected.

Rectus Capitis Lateralis (Fig. 230).—**Origin,** the transverse process of the atlas; **insertion,** the jugular process of the occipital bone; **action,** lateral flexion of the head; **nerve-supply,** the first cervical nerve.

Removing the anterior scalene muscle and displacing the anterior divisions of the cervical nerves, the middle scalene muscle should be cleaned.

Scalenus Medius (Fig. 228).—**Origin,** the posterior tubercles of the transverse processes of all the cervical vertebræ except, usually, the atlas; **insertion,** the upper surface of the first rib behind the subclavian groove; **action,** to raise the first rib and thus assist in inspiration, or, when the ribs are fixed, to flex the neck; **nerve-supply,** the lower six cervical nerves.

The relation of this muscle to the brachial plexus, the posterior thoracic nerve and the subclavian artery has been seen (pp. 357 and 358). The muscle should be separated from the posterior scalene muscle and then removed.

Scalenus Posticus (Fig. 228).—**Origin,** the posterior tubercles of the transverse processes of the lower two or three cervical vertebræ; **insertion,** the upper surface of the second rib; **action,** that of the preceding muscle but in a less degree; **nerve-supply,** the lower three cervical nerves.

The Second Portion of the Vertebral Artery.—The *first portion* of the vertebral artery has been traced to the foramen of the sixth cervical transverse process (p. 366). The *second part* of the vessel is now to be

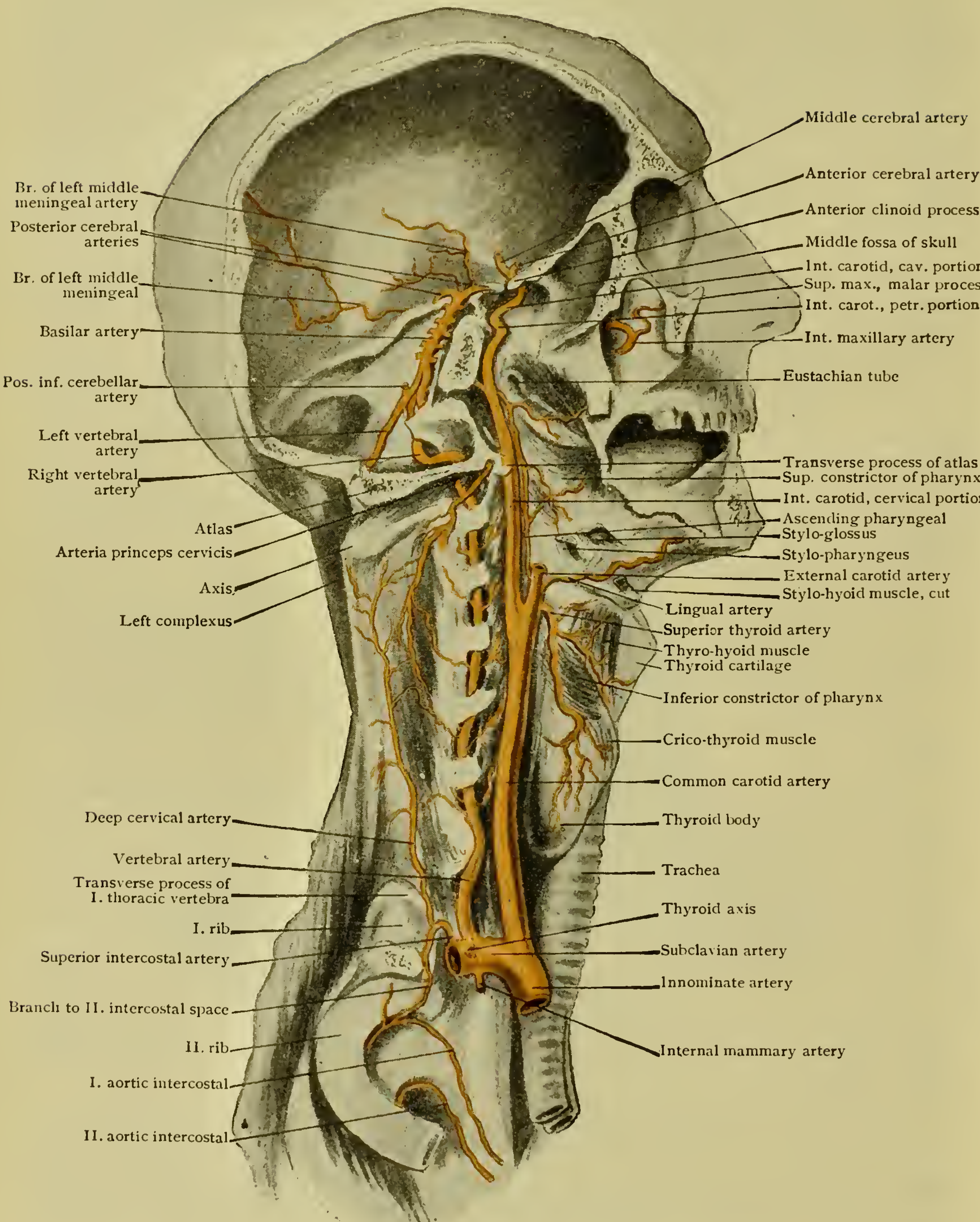

FIG. 229.—Deep dissection, showing internal carotid, vertebral and superior intercostal arteries.

exposed as it passes upward through the foramina of the transverse processes of the upper six cervical vertebræ (Fig. 229) by removing all shreds of muscular and tendinous tissue from the front surfaces of the transverse processes and also from between them. If the artery is not well injected it may be hard to find, especially as it is masked by a plexus of veins and an interlacement of sympathetic nerve-fibres (p. 366).

The **cervical branches,** given off at each intervertebral space, are the *lateral* or *muscular* and the *medial* or *spinal.*

The **muscular branches** go to the muscles of the neck, inosculating with the ascendens, the profunda and the princeps cervicis.

The **spinal branches** pass through the intervertebral foramina to assist in the supply of the spinal cord and the bones and ligaments of the spine, in connection with which they are considered (p. 591).

After isolating the artery and some of these branches, note its position in front of the anterior divisions of the cervical nerves except that of the first nerve, to which it is external. Now trace it backward around the outer side of the upper articular process of the atlas to the groove on the upper surface of the posterior arch of that bone, from which it is separated by the suboccipital nerve, and to the point where, as an occupant of the suboccipital triangle (Fig. 172), it pierces the posterior occipito-atlantal ligament to enter the spinal canal and finally to traverse the foramen magnum. Its further course will be seen in dissecting the blood-vessels of the brain (p. 498).

THE JOINTS OF THE SPINAL COLUMN.

Each vertebra is united with the next one above and the next one below by the articulations of the bodies or centra and those of the articular processes. These connections are supplemented by ligaments connecting neighboring spinous processes, transverse processes and laminæ.

The **spinous processes** are connected by the *supraspinous* and the *interspinous ligaments.* The **supraspinous ligaments** are bands that connect the tips of the spinous processes; they are represented in the cervical region, however, by the ligamentum nuchæ. The **interspinous ligaments** connect the contiguous margins of the spinous processes; they are feebly developed in the neck.

The **transverse processes** are connected by the *intertransverse ligaments,* which are poorly represented in the neck, are rounded cords in the thoracic region and membranous bands in the lumbar region.

The ligaments of the laminæ are to be examined later (p. 492).

The Joints of the Articular Processes.—A **capsular ligament** connects the margins of the opposed articular processes. This should be examined in the case of one or two joints and should then be incised

to expose the articular surfaces (Fig. 230). The joints are of the **arthrodial** type. Note the differences of the articular processes of different regions of the spine as to the direction of the planes of the articular surfaces—differences bearing directly on the varying degrees of mobility of the different regions.

THE INTER-CENTRAL ARTICULATIONS.—The connection between the centra or bodies of the vertebræ, **amphiarthrodial joints,** is effected by the *intervertebral disks* and the *anterior* and the *posterior common ligament.*

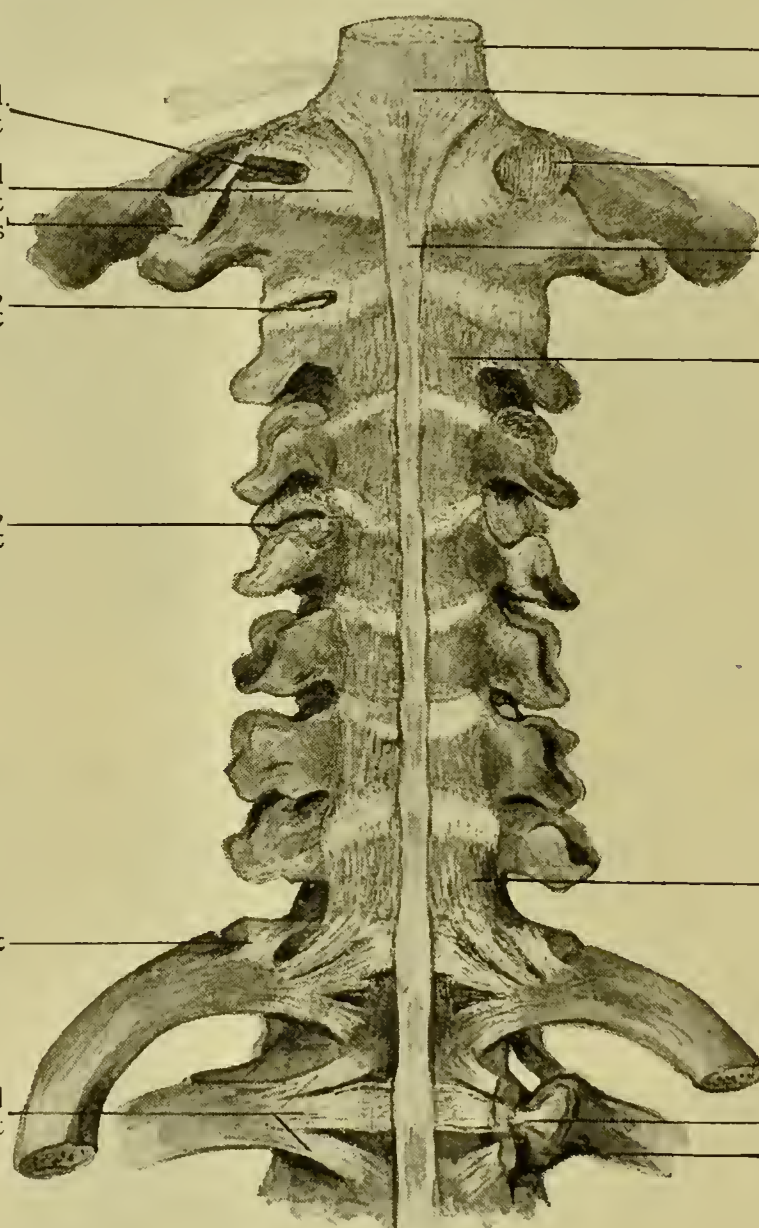

FIG. 230.—The ligaments of the anterior aspect of the spine, the costo-vertebral joints and the anterior aspect of the occipito-atlantal joints.

The **anterior common** or **longitudinal ligament** (Fig. 230) is a broad strong band extending from the base of the sacrum to the body of the axis, where it becomes continuous with the anterior atlanto-axial ligament. Note the strong fibrous character, the greater width in the lower part of the spine and the greater thickness in the thoracic region. Demonstrate the firmness of its attachments, especially to the disks, by trying to reflect a portion of it.

The **posterior common** or **longitudinal ligament** can only be seen after removing the neural arches, since it is on the posterior surfaces of the centra; it is continuous above with the posterior occipito-axial ligament and extends down to the sacrum.

The **intervertebral disks** or **fibro-cartilages** are to be noted as conforming in shape to that of the vertebral bodies with which they are in contact and as being relatively thickest in the cervical spine. The individual disks also vary in thickness in the curved portions of the spine in adaptation to these curves. Examining the disk that was cut in dividing the spinal column between the third and the fourth vertebra, note the pulpy character of its central part (*nucleus pulposus*) and the fibrous peripheral portion (*annulus fibrosus*).

The articulation between the first and the second cervical vertebra (atlas and axis) differs essentially from the other vertebral joints; it is to be dissected after the examination of the joint between the axis and the occipital bone.

THE ARTICULATION OF THE SPINE WITH THE SKULL.

This connection includes the joining of the atlas with the occipital bone and the connection of the axis with the latter by certain ligaments.

THE OCCIPITO-ATLANTAL ARTICULATIONS.—The **articular surfaces** involved in these condyloid joints are those of the articular processes of the atlas and of the condyles of the occipital bone. The **ligaments** are a *capsular ligament* for each joint, and the *anterior* and the *posterior occipito-atlantal ligament*.

The **anterior occipito-atlantal ligament** (Fig. 230) should be cleaned and examined and its attachment below to the entire upper border of the anterior arch of the atlas and above to the anterior margin of the foramen magnum noted. On each side it is practically continuous with the capsular ligaments.

The **posterior occipito-atlantal ligament** is to be exposed by removing the posterior straight and the oblique muscles, the neck being sharply flexed over a block beneath its anterior surface. Note its looseness, its attachments to the posterior arch of the atlas and the posterior margin of the foramen magnum and its deficiency on each side where the suboccipital nerve and the vertebral artery pass between it and the arch of the atlas (Fig. 172).

The **capsular ligaments** envelop the condyles of the occipital bone and the lateral masses of the atlas. Noting these attachments, the capsule of one side may be cut (Figs. 230 and 232) to expose the cavity and the **synovial membrane.**

THE ATLANTO-AXIAL ARTICULATIONS.—The joints between the lower articular surfaces of the atlas and the upper surfaces of the axis

are of the **arthrodial type,** the related processes being connected with each other by *capsular ligaments.* Note the anterior and posterior aspects of the joints and then incise one of the capsules.

The **anterior atlanto=axial ligament** should be noted as a broad band connecting the front of the body of the axis with the anterior arch of the atlas (Fig. 230). Its relation with the anterior common ligament and with the greater anterior straight muscles was seen in dissecting those structures.

The **posterior atlanto=axial ligament** connects the laminæ of the axis with the posterior arch of the atlas and hence is the representative here of the ligamenta subflava (*vide infra*).

The other elements of the atlanto-axial articulations, the joints between the odontoid process of the axis and the atlas, and its transverse ligament will be seen at a later stage (p. 494).

The posterior arch of the atlas, the laminæ of the axis and those of the remaining cervical vertebræ—if the latter still remain—must be sawn through so as to divide the neural arches of the vertebræ near their attachments to the centra. The saw should cut the arches a little to the inner side of the articular processes and should be applied as if to hit the centre of the spinal canal. The section is to be made with sufficient care to avoid injuring the spinal dura mater and to preserve the sawn-out segment of the spine in one piece. The posterior part of the occipital bone may be first removed by a saw-cut behind the foramen magnum if desired.

The periosteum of the spinal canal, the blood-vessels, the dural sheath of the cord and the spinal nerve-roots are considered elsewhere (p. 588); in this dissection, however, the dura mater should be laid open by a median longitudinal incision and the **spinal portion of the spinal accessory nerve** should be sought within the dural sheath. It ascends beside the spinal cord from the level of the sixth cervical nerve, receiving accessions of fibres from the latter level to the upper extremity of the cord (Fig. 282), and passes through the foramen magnum into the skull (p. 369).

The ligaments connecting the vertebral laminæ are now to be examined. They are the **ligamenta subflava,** bands of yellow elastic tissue which are practically hidden by the laminæ in the uncut spinal column. Upon examining the deep surface of the piece just sawn out (Fig. 231), each ligamentum subflavum is seen to be attached to the deep surface and lower border of the lamina above and to the posterior surface and upper border of the lamina below, the upper line of attachment extending from the articular process to the junction of the laminæ of the two sides and the lower line to the root of the spinous process. The thickened part of the mesial border of each ligament is in close relation with its fellow, the small hiatus being occupied by areolar tissue and small

emerging veins. The strength and elasticity of these ligaments serve an important purpose in maintaining the erect attitude of the spine and in resuming it after the spine has been flexed.

The upper end of the spinal cord should now be turned downward (Fig. 232) or the upper segment removed, the anterior portion of the dural sheath being taken away from the front wall of the canal.

The **posterior common ligament** (p. 491) is now exposed to view (Fig. 232) and appears as if continued directly upward to the cranial surface of the basilar process in front of the foramen magnum. That part of it above the lower border of the axis presents some special features and receives a special name, the *posterior occipito-axial ligament.*

FIG. 231.—Ligamenta subflava. The neural arches of the cervical and first and second dorsal vertebræ removed by saw-cuts close to articular processes, to show the ligamenta subflava as seen from within the spinal canal. The lower part of the specimen has been turned to show the spinous processes.

THE OCCIPITO-AXIAL LIGAMENTS.—The axis and the occipital bone do not come in contact with each other but are connected by the *posterior occipito-axial* and the *three odontoid ligaments.*

The **posterior occipito-axial** ligament (membrana tectoria, apparatus ligamentosus) is attached below to the posterior surface of the body of the axis and above to the upper aspect of the basilar process in front of the foramen magnum. It is the specially developed upper portion of the posterior common ligament. Cut it transversely near its upper end and turn it downward, detaching it carefully from the underlying odontoid and transverse ligaments (Fig. 232).

The **middle odontoid** or **suspensory ligament** (lig. apicis dentis) is to be followed from the apex of the odontoid process to the anterior margin of the foramen magnum (Fig. 232), after cutting and reflecting the upper limb of the cruciform ligament (see below) which overlies it.

The **lateral odontoid** or **check liagments** (ligg. alaria) are seen to pass from each side of the apex of the odontoid process respectively to the impression on the inner side of the condyle of the occipital bone (Fig. 232).

The Atlanto-Axial Articulations (continued).—The joints between the articular processes of the axis and atlas have been considered (p. 491).

It remains to examine the connection between the odontoid process and the anterior arch of the atlas, which includes two distinct joints.

The **transverse ligament of the atlas** (Fig. 232) should be noted as being attached at each end to the tubercle on the inner surface of the lateral mass of the atlas and to be continuous in its central part with an *ascending* and a *descending band*, the whole presenting a cruciform appearance and being designated the **ligamentum cruciatum.** The *upper limb* covers the suspensory ligament and is attached to the anterior

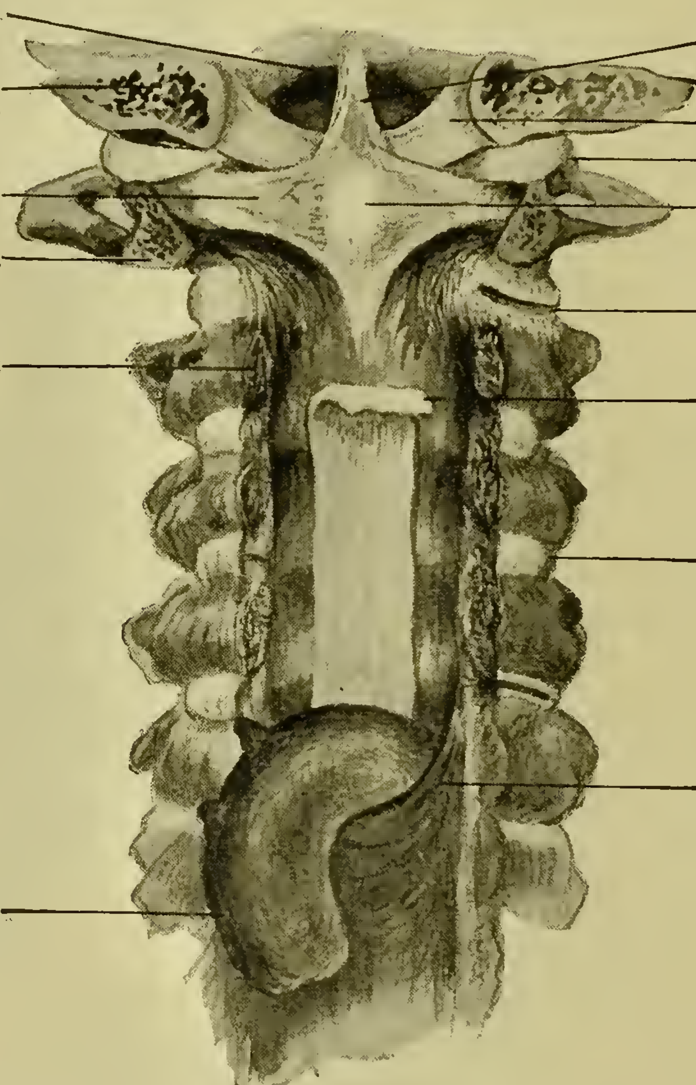

Fig. 232.—Upper part of spinal canal opened by sawing through neural arches, to show ligaments of spine and occipital bone.

margin of the foramen magnum; the *lower limb* is attached to the body of the axis. Now detaching the lower limb, try to separate the transverse ligament from the odontoid process and note the close connection of the two and the **synovial membrane,** sometimes called a bursa, between them; incising the ligament and the capsule, note the cartilage-encrusted facet on the odontoid process. The **accessory atlanto-axial** ligaments are two bands, each passing upward and outward from the base of the odontoid process to the lateral mass of the atlas; in some instances they seem to be thickened parts of the capsules of the atlanto-axial joint (Fig. 232).

The **joint between the front of the odontoid process and the anterior arch of the atlas** is surrounded by a *capsular ligament.*

The Movements of the Head.—The nodding movements of the head, *flexion* and *extension*, occur at the occipito-atlantal joints, which may also permit very slight lateral flexion and rotation. *Rotation of the head* is due to movement between the axis and atlas, the latter bone turning with the skull; the check ligaments limit the degree of rotation.

THE COSTO-VERTEBRAL ARTICULATIONS.

Although the costo-vertebral articulations properly belong to the dissection of the thorax, it is convenient to dissect them on this detached portion of the preparation.

The articulation of the ribs with the spinal column is effected by the connection between the heads of the ribs and the bodies or centra of the vertebræ and by that between the tubercles of the ribs and the vertebral transverse processes.

The Costo-Central Articulations.—The **articular surfaces** typically concerned in these **arthrodial joints** are the two facets on the mesial surface of the head of the rib, the facets on the upper and lower borders of the lateral aspects of the two contiguous vertebræ and the interposed disk with which each rib articulates. The exceptions are the first, tenth, eleventh, and twelfth ribs, each of which articulates with only one vertebra.

The **ligaments** are the *anterior costo-vertebral*, the *capsular* and the *interarticular*.

The **anterior costo-vertebral** or **stellate ligament** (lig. capituli costæ radiatum) consists of three flat bands which diverge from their attachment to the front of the head of the rib to be connected, one each, with the two vertebræ and the intervertebral disk (Fig. 230), the upper band, in the case of the first joint, passing to the seventh cervical vertebra.

The **capsular ligament** surrounds the joint loosely; it should be exposed more completely by removing the stellate ligament.

The **interarticular ligament** is to be exhibited by cutting the capsule (Fig. 230), when it is seen to connect the crest between the two articular facets on the head of the rib with the intervertebral disk. It divides the joint into an upper and a lower compartment, each with its own **synovial membrane,** except in those joints named above in which the rib articulates with but one vertebra.

The Costo-Transverse Articulations.—The **articular surfaces** are on the posterior aspect of the tubercle of the rib and the anterior surface of the transverse process. The eleventh and twelfth ribs, having no tubercles, do not form these joints. The joints are arthrodial.

The **ligaments** are the *capsular* (Fig. 230) and the *three costo-transverse.*

The **anterior** or **superior costo-transverse ligament** connects the crest on the upper border of the neck of the rib with the lower border of the transverse process above it (Fig. 230).

The **posterior costo-transverse ligament,** seen from behind, connects the tip of the transverse process with the tubercle.

The **middle** or **interosseous ligament** connects the opposed surfaces of the transverse process and of the neck of the rib. It may be seen by separating the neck of the rib from the transverse process or by making a horizontal section of them.

THE DISSECTION OF THE BRAIN.

The brain may be removed from the hardening fluid and placed in an inverted position upon a nest of cotton or cheese-cloth.

Since in the work that is now to be undertaken it will be necessary to refer to parts not yet described, the student must acquire a general knowledge of the topography of the brain before beginning his work.

Each **hemisphere** (p. 322) is subdivided into *lobes* by more or less conspicuous **fissures.** Thus on the *convex* or *outer surface,* the **fissure of Rolando,** running downward and forward, separates the **frontal lobe** from the **parietal lobe** (Fig. 236); the **fissure of Sylvius** indicates the division between the **temporal lobe** which lies below it and the frontal and parietal lobes which lie above it (Fig. 236), while the **external parieto-occipital fissure** seems in a measure to mark off the **occipital lobe** from the parietal and temporal lobes. On the *under surface of the hemisphere,* the frontal lobe is separated from the temporal lobe by the beginning of the Sylvian fissure, the latter arising at a depression, the anterior perforated space (Fig. 233).

On the *mesial surface of the hemisphere* (Fig. 241), the **internal parieto-occipital fissure** more completely delimits the occipital from the parietal lobe, though the former lobe is continuous almost without interruption with the temporal lobe. The *ramus marginalis* of the **calloso-marginal fissure** indicates the division between the frontal and parietal lobes. The lobes and fissures are more fully considered later (p. 504 et seq.).

THE BLOOD-VESSELS AT THE BASE OF THE BRAIN.—Having removed the arachnoid (p. 327), the blood-vessels at the base of the brain are exposed. The two **internal carotid arteries** and the **basilar artery** (the latter resulting from the union of the two vertebral arteries) form by their communications with each other the **circle of Willis** (Fig. 233). These trunks should be denuded by picking up any remaining portions of brain membrane and removing them, preferably by the use of the scissors. This process may be begun at the stumps of the internal carotid arteries, noting the **anterior choroid branch** which arises from the

internal carotid and passes backward and outward to enter the descending horn of the lateral ventricle to supply its choriod plexus; the **posterior communicating artery,** a branch of the internal carotid, will also be found in connection with this part of that vessel.

The **middle cerebral artery,** one of the terminal branches of the internal carotid, may be traced to its point of entrance into the fissure of

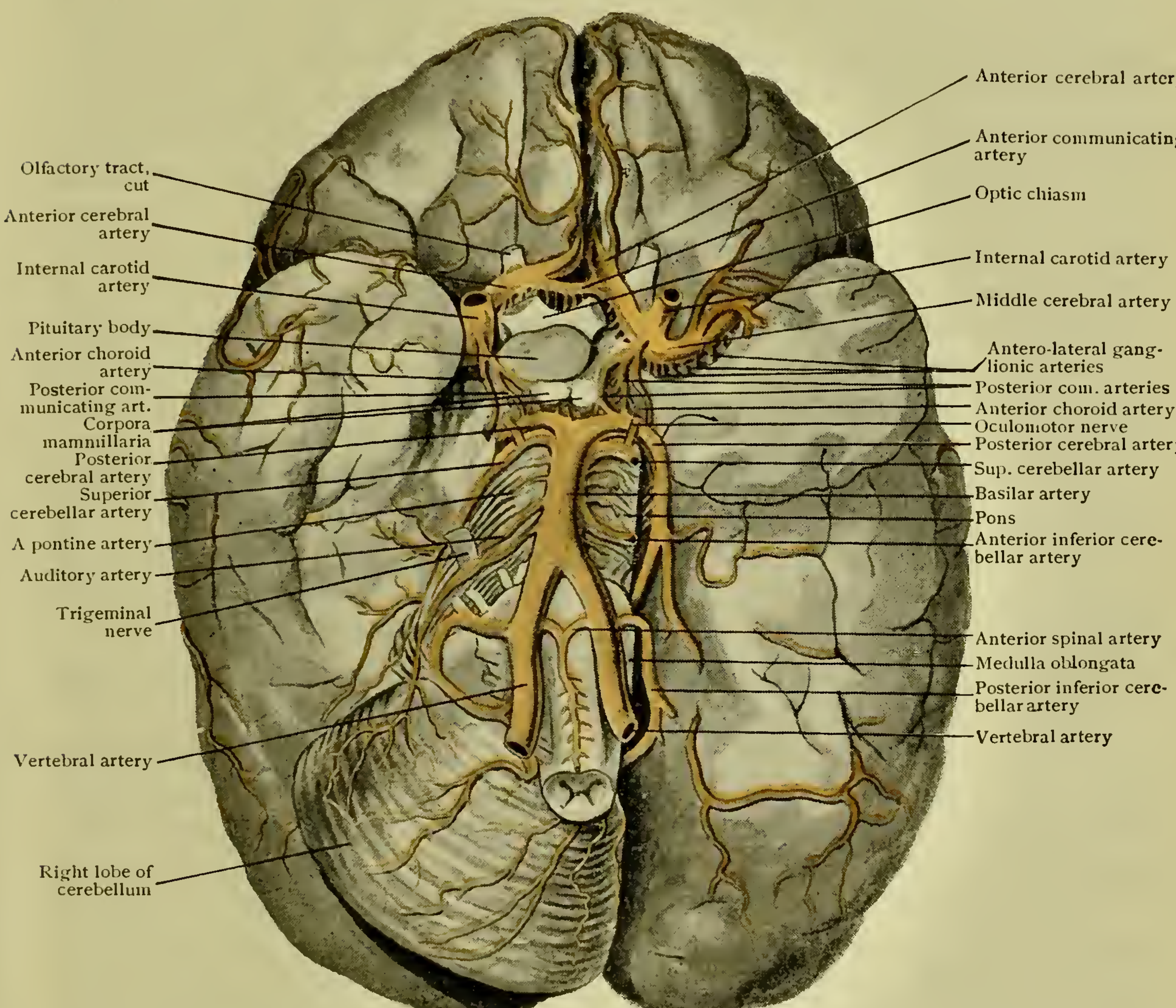

FIG. 233.—The arteries at the base of the brain. The left half of the cerebellum and the apex of the left temporal lobe have been removed.

Sylvius, its further course in which fissure on the convex surface of the hemisphere will be worked out in a later stage of the dissection. The **antero=lateral ganglionic branches** of the middle cerebral are to be avoided in denuding the vessel, these appearing as small vessels coming off at right angles from their parent trunk. The inner group of them, known as the *internal striate vessels*, perforate the base of the brain to penetrate the inner part of the lenticular nucleus, the caudate nucleus and the internal capsule, and include the *lenticulo-striate artery* (Charcot's artery

of cerebral hemorrhage); the outer group, the *external striate vessels*, pass to the outer portion of the lenticular nucleus and adjacent territory.

The **anterior cerebral artery,** the smaller of the terminal branches of the internal carotid, will be found passing inward and forward to reach the great longitudinal fissure, having entered which it curves upward over the anterior extremity of the corpus callosum to supply the mesial surfaces of the frontal and parietal lobes (p. 500). The dissector will note the communication between the two anterior cerebral arteries by means of the **anterior communicating,** a small transverse branch connecting the vessels near their entrance into the longitudinal fissure. The **antero-median ganglionic branches** of the anterior cerebral, arising also in part from the anterior communicating artery, are small branches passing backward to supply the adjacent structures such as the lamina cinerea, the tuber cinereum, the pituitary body, etc.

The **fourth portions** of the **vertebral arteries** (p. 487), found in this dissection, should now receive attention and their **branches,** the *posterior meningeal*, the *posterior spinal*, the *anterior spinal* and the *posterior inferior cerebellar*, should be identified and traced.

The **posterior meningeal branch** is distributed to the dura mater of the posterior fossa (Fig. 233).

The small **posterior spinal branch** leaves the cranial cavity by way of the foramen magnum to pass down the spinal canal upon the posterior aspect of the spinal cord (p. 591).

The larger **anterior spinal branch** arises near the termination of the vertebral and speedily unites with its fellow of the opposite side to form a common median trunk (Fig. 233), which, passing through the foramen magnum, traverses the entire length of the spinal canal in relation with the anterior surface of the cord, communicating with those vessels which enter the canal through the intervertebral foramina (p. 489).

The **posterior inferior cerebellar artery** should be traced to the back part of the under surface of the cerebellum (Fig. 233).

The **basilar artery,** the large trunk resulting from the union of the two vertebral arteries, lies in relation with the ventral surface of the pons and **terminates** near its upper extremity by dividing into the two *posterior cerebral arteries*.

The **branches of the basilar artery** are the *transverse branches*, consisting of several small vessels which diverge from the parent trunk at a right angle over the ventral surface of the pons; the *internal auditory artery*, which passes transversely outward to finally reach the internal auditory meatus, which it enters and traverses on its way to its destination in the internal ear; the *anterior inferior cerebellar artery* going to the front part of the under surface of the cerebellum, and the *superior cerebellar*, which reaches the dorsal surface of the cerebellum.

The **posterior cerebral arteries,** the terminal branches of the basilar, diverge laterally and then pursue a course backward and outward to reach the mesial aspect of the temporal lobe of the cerebrum. The **branches** visible at this stage are the *postero-median ganglionic*, which arise from the anterior aspects of the vessels near their origin and which perforate the brain substance at the posterior perforated area to supply the optic thalamus and adjacent parts; the *postero-lateral ganglionic* (Fig. 233), also small vessels which arise from the artery more distally; the *posterior choroid artery*, which reaches the velum interpositum and thus the choroid plexus of the third ventricle by passing through the transverse fissure of the brain (Fig. 235). The student will note, after completing the dissection of these vessels, that by this communication between the posterior and middle cerebrals, by the communication between the anterior cerebrals of the two sides by means of the anterior communicating artery, and by the common origin of the posterior cerebrals from the basilar, a complete arterial circle is formed, the **circle of Willis** (Fig. 233).

The small groups of **ganglion branches** of the circle of Willis are noteworthy for several reasons: their *size;* the *angle* at which they spring from their parent trunks, which may have some effect in mitigating the force of the cardiac impulse; the fact that they constitute a definite system, the **ganglionic system,** for the supply of the basal ganglia and adjacent parts; and that they are *end arteries*, *i.e.*, that each terminal branch ends without communication with its neighbors and therefore supplies a definite wedge-shaped area. Owing to this arrangement, obstruction of one of these vessels deprives a definite region of its blood-supply and therefore of its function.

THE ARTERIES OF THE CONVEX SURFACE OF THE HEMISPHERE.—The brain may now be turned over, the inequalities upon its under surface being accommodated by a crumpled piece of damp cheese-cloth or by damp cotton so as to prevent mutilation of the parts, and the arteries on the convex surface may be dissected.

The **middle cerebral artery,** which was seen to enter the beginning of the fissure of Sylvius, follows that fissure to the lateral aspect of the hemisphere, giving off various **branches** in its course. The *inferior frontal branch* (Fig. 234) going to the inferior frontal convolution, the *ascending frontal* passing upward in front of the fissure of Rolando along the ascending frontal convolution, the *parietal branch* to that part of the parietal lobe which is adjacent to the fissure of Sylvius, the *parieto-temporal branch* passing to the upper and posterior portion of the temporal lobe and to the back part of the parietal, should all be dissected in turn and traced throughout their ramifications.

A few branches of the anterior cerebral artery turn around the mesial border of the frontal lobe from the anterior part of the longitudinal fissure (Fig. 234); some branches of the posterior cerebral, as the *calcarine*

and the *parieto-occipital*, will be found turning round the posterior part of the mesial edge of the hemisphere to reach the convex surface.

THE ARTERIES ON THE MESIAL SURFACE OF THE HEMISPHERE.—These vessels, although not accessible at the present stage of the dissection, may be considered now as a matter of convenience (p. 515).

The **anterior cerebral artery,** which was seen to enter the longitudinal fissure (Fig. 233), passes upward and forward around the genu of the corpus callosum (Fig. 235), finally terminating at the convolution known as the precuneus, situated just in front of the parieto-occipital fissure. Its **branches** (see also p. 498) are the *internal orbital* to the

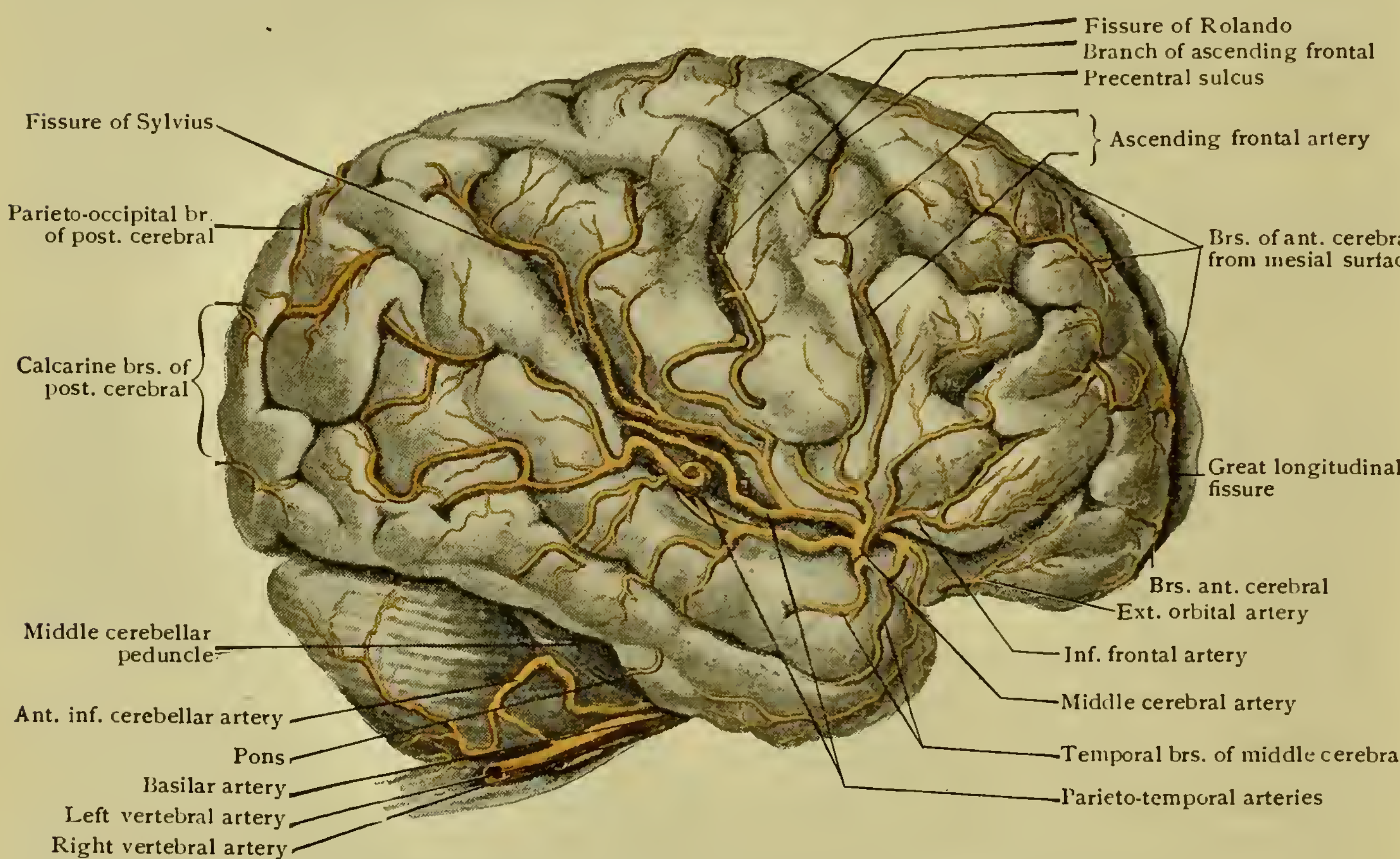

FIG. 234.—Arteries of lateral surface of right cerebral hemisphere.

orbital surface of the frontal lobe (Fig. 235), the *anterior internal frontal*, the *middle internal frontal* and the *posterior internal frontal* or *quadrate* (Fig. 235), these supplying, in addition to the orbital surface of the frontal lobe, the mesial aspect of the frontal and parietal lobes as far back as the parieto-occipital fissure.

The **posterior cerebral artery,** the origin of which has been seen (p. 499), having passed outward across the crus cerebri, gains the mesial aspect of the temporal lobe, passing then backward and upward to terminate in the parieto-occipital fissure. The **branches,** in addition to those already encountered (p. 499), are the *anterior temporal*, to the anterior part of the uncinate gyrus, the *posterior temporal*, to the posterior part of the same gyrus, the *calcarine*, passing along the calcarine fissure, and the *parieto-occipital* to the parieto-occipital fissure.

Having dissected these vessels and studied their distribution, the convex surfaces of the brain hemispheres may be entirely denuded of any remaining parts of the membranes as well as of the vessels themselves. Before removing the pia mater from the base of the brain, it is desirable to identify and isolate the attached portions of the cranial nerves in order to effectually safeguard them. Nor should the pia mater between the cerebrum and the cerebellum, or that between the cerebellum and the medulla be disturbed, it being desirable to leave these portions of the pia until a subsequent stage of the dissection.

As previously pointed out, the pia mater is the vascular membrane of the brain and gives support to its blood-vessels. The **larger vessels,** which ramify upon the surface, give off **two sets of branches,** the *short* or *cortical vessels*, distributed to the

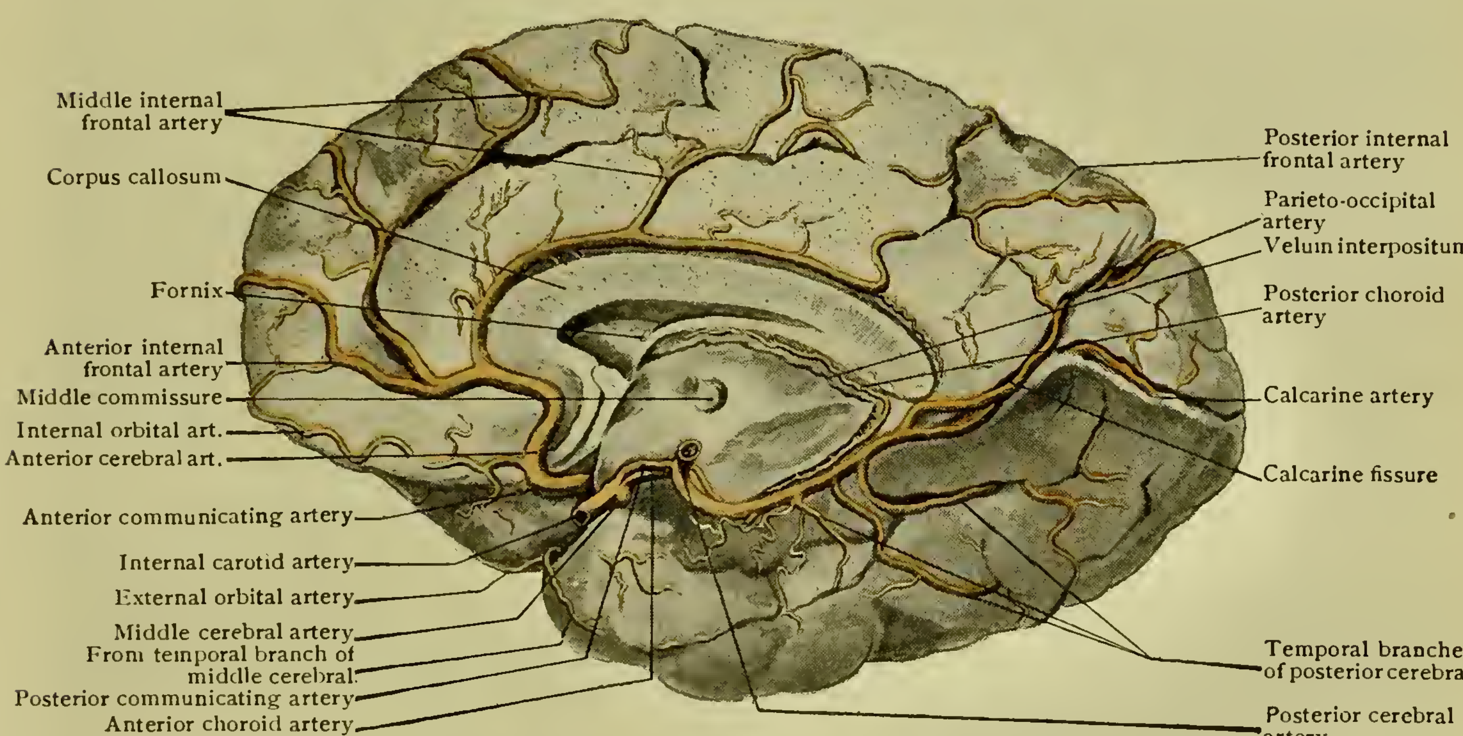

FIG. 235.—Mesial surface of right cerebral hemisphere, showing cortical branches of anterior and posterior cerebral arteries.

cortex or surface gray matter, and the *long* or *medullary arteries* which pass more deeply to reach the central white or medullary substance. The vessels composing these two systems are for the most part terminal or end-arteries, although they are not so strictly so as are the vessels of the ganglionic system.

The brain should be again placed in the inverted position.

THE POINTS OF ORIGIN OF THE CRANIAL NERVES.—The twelve pairs of cranial nerves are designated numerically according to the order in which they make their appearance upon the surface of the brain from before backward, these points being known as their points of **superficial origin**. Their **deep origins** correspond with the situation of the nuclei within the brain substance with which they are connected; these will be considered subsequently. The **first** or **olfactory nerves** (p. 328) make their appearance upon the under surface of the olfactory bulb

(Fig. 166). The posterior end of the olfactory bulb is connected by means of the **olfactory tract,** a somewhat flattened band, with the surface of the brain apparently at the anterior perforated area, upon approaching which area the tract divides into a **mesial** and a **lateral root.** The bulb and tract, often incorrectly referred to as the olfactory nerve, are really a part of the **olfactory lobe** of the brain, which in man is quite rudimentary as compared with the olfactory lobe of the osmatic mammals (p. 509).

The **second** or **optic nerves** are traceable to the **optic chiasm** or **commissure,** from which structure the **optic tract** of each side, a somewhat flattened band, passes backward across the ventral surface of the crus cerebri close to its entrance into the cerebral hemisphere (Fig. 166.)

The **third** or **oculomotor nerves** make their appearance at the apex of the inter-peduncular space, therefore just back of the posterior perforated lamina (p. 503).

The **fourth** or **trochlear nerves** make their appearance on this aspect of the brain at the outer border of the ventral surface of the crus, but their actual superficial origin is the dorsal surface of the valve (p. 534).

The **fifth** or **trifacial nerve** is seen to be connected by two strands of unequal size with the ventro-lateral surface of the pons, upon the larger of which, the *sensory root* of the nerve, is found the **Gasserian ganglion** (p. 335), the smaller strand being the *motor root* (Fig. 166).

The **sixth** or **abducent nerves** appear at the lower border of the pons not far from the mid-line (p. 329).

The **seventh** or **facial nerves** are encountered also at the lower border of the pons, immediately to the outer side of which will be found a smaller strand, the **pars intermedia** (Fig. 166).

The **eighth** or **auditory nerves** likewise make their appearance at the lower border of the pons upon the outer side of the pars intermedia.

The **ninth** or **glosso=pharyngeal,** the **tenth** or **vagus** (p. 539) and the **eleventh** or **spinal accessory** (pp. 369 and 492) **nerves** appear as a series of strands on the lateral surface of the medulla in a groove known as the dorso-lateral fissure of the medulla (Fig. 166).

The **twelfth** or **hypoglossal nerves** appear upon the lateral surface of the medulla as a series of strands between the olivary body and the pyramidal body in series with the anterior roots of the spinal nerves.

Each of these nerves should be isolated so that the dissector may see clearly their points of connection with the under surface of the brain.

Whatever shreds of membrane still adhere to the under surface of the brain after the isolation of the blood-vessels and nerves mentioned above should now be cleared away by the use of forceps and scissors. The anterior part of the great longitudinal fissure is now well demonstrated and may be seen to present in its depths the anterior portion of

the corpus callosum. The **optic commissure** should be gently elevated to expose that portion of the brain substance known as the **lamina cinerea,** a vertical sheet which constitutes the anterior wall of the third ventricle. Immediately back of this, the conical, projecting **tuber cinereum** is seen, from the apex of which, looking forward in this position of the brain, projects a rounded mass about one fourth inch in length, the **infundibulum**; upon the summit of this is a flattened globular mass, the **pituitary body.** The pituitary body is sometimes left in the pituitary fossa in removing the brain from the skull, the infundibulum being torn close to its attachment to the pituitary body. Behind the tuber cinereum are two small, rounded bodies, one on either side, the **corpora albicantia** or **mammillaria.** The **posterior perforated space** is situated behind the corpora albicantia and is bounded on each side by the **crura of the cerebrum** as they diverge from the upper border of the pons toward the hemisphere of each side, enclosing the **interpeduncular space.** The ventral surfaces of the crura cerebri should be carefully denuded, when it will be evident that they present a longitudinal striation significant of the fact that the ventral portions of these bodies are made up of bundles of fibres on their way from the cerebral hemisphere of the corresponding side to the pons. The surface of the **pons** should be denuded of any adhering shreds of membrane and its mesial longitudinal groove for the accommodation of the basilar artery noted. It can be seen with the naked eye that this ventral surface of the pons presents a transverse striation corresponding with the direction of its bundles of fibres. Tracing this ventral surface laterally it will be seen that the surface narrows or, in short, that the superficial transverse fibres of the pons become a somewhat rounded bundle and that this passes into the cerebellum as the **middle peduncle of the cerebellum.** The **ventral surface of the medulla,** when freed from adhering membranes, presents a mesial groove, the **ventro-mesial fissure,** which may be seen to be interrupted or encroached upon by obliquely directed strands due to the decussation of the larger portion of the efferent fibres which constitute the **anterior pyramids** of the medulla. The latter are the rounded longitudinal elevations, larger above than below, which lie one upon either side of the ventro-mesial fissure (Fig. 166).

THE TELENCEPHALON OR CEREBRAL HEMISPHERES.

The chief part of the bulk of the cerebral hemispheres is made up of nerve-fibres, the **white substance of the hemispheres,** the relatively thin shell of **brain-cortex** or **cortical gray matter** consisting of nerve-cells from which these fibres emanate as axones or to which they go as dendrites of other cells situated in other parts of the nervous system. Hence, in a sense, the cortex is the most important part of the brain

and its superficial extent becomes an index of the degree of brain development. But greater superficial extent is obtained by convolutions or foldings of the cortex, the grooves between which are known as fissures. The study of these convolutions and fissures is therefore of great importance, since in the former are located the various motor and sensory centres, as well as the centres of intellection.

THE SURFACE OF THE CEREBRUM.

The surface of the cerebrum is divided into **lobes** by more or less deep indentations or **fissures** (p. 496). The subdivisions of the lobes which are brought about by the presence of **secondary fissures** or **sulci** are known as **convolutions** or **gyri**. The anterior extremity of the hemisphere is known as the **frontal pole,** the posterior extremity as the **occipital pole,** and the part which projects forward and somewhat downward as the **temporal pole** of the hemisphere.

The Convex Surface of the Hemisphere.—The **fissure of Rolando** or the **central fissure** (sulcus centralis) passes from or near the mesial border of the hemisphere downward and forward in a somewhat sinuous line to terminate just short of the fissure of Sylvius (Fig. 236). The *superior knee or genu* is a posteriorly projecting angle at the upper third of the fissure; the *inferior genu* projects forward at about its middle. The upper extremity of the Rolandic fissure is approximately a half-inch behind the middle of the mesial border of the hemisphere and may be recognized by its direction and evident importance, and by the fact that just in front of and approximately parallel with it is the precentral fissure, less conspicuously marked, and that behind it, also approximately parallel with it, is the postcentral fissure, the latter curving backward above to run parallel with the mesial border of the hemisphere. The fissure of Rolando forms with the mid-line an angle of 71.7 degrees. A further aid to the recognition of this fissure is to recognize the quite conspicuous upturned end of the calloso-marginal fissure on the mesial aspect of the hemisphere near its upper border, the fissure of Rolando being the first fissure of any importance in front of this one. The region in front of the fissure of Rolando is the frontal lobe, while immediately behind it is the parietal lobe. The student should pull apart the lips of the fissure to gain an idea of its depth.

The **fissure of Sylvius** (fissura cerebri lateralis), beginning on the under surface of the hemisphere at the vallecula Sylvii immediately external to the anterior perforated lamina, passes outward to the convex surface of the hemisphere, where it divides into three fissures or branches. The **posterior branch** turns backward and later slightly upward and then more markedly upward to terminate in the back part of the parietal lobe. This fissure separates the frontal and parietal lobes

which lie above it from the temporal lobe below. The **anterior ascending limb** of the fissure of Sylvius passes off from the main fissure upward and somewhat forward into the lower part of the frontal lobe; the **anterior horizontal branch** passes forward into the frontal lobe. These may arise from the main fissure by a common stem. If the student will separate the lips of the fissure of Sylvius near the fore part of the temporal lobe he will discover what appears to be a small crumpled mass lying in its depths; this is a distinct lobe of the brain known as the **insula** or **island of Reil.**

The **parieto-occipital fissure,** seen chiefly on the mesial surface of the hemisphere (Fig. 241), appears to only a limited extent on the convex surface in the form of a short but well marked groove extending from the posterior part of the mesial border of the hemisphere somewhat below the back part of the fissure of Sylvius. It indicates the line of demarcation, so far as it goes, between the parietal lobe in front and the occipital lobe behind, this line of demarcation being further indicated by a line drawn from the parieto-occipital fissure downward and forward to the *pre-occipital notch*, the latter being an indentation on the lower border of the hemisphere about one third the distance from its posterior to its anterior extremity (Fig. 236).

The **frontal lobe,** bounded behind by the Rolandic or central fissure, is subdivided by an approximately vertical fissure, the **precentral** or **ascending frontal sulcus,** usually divided into a *superior* and an *inferior* part, and by two horizontal fissures situated in advance of the latter, the **first** and **second frontal fissures.** The **precentral convolution** is that part of the frontal lobe which lies behind the precentral sulcus. The **first, second** and **third,** or the **superior, middle** and **inferior convolutions** are situated respectively above the first frontal fissure, between the first and second and below the second. The **inferior frontal convolution** is further subdivided by the horizontal and ascending rami of the fissure of Sylvius into the **pars orbitalis,** situated nearest the lower border of the hemisphere, the **pars triangularis** between the two subdivisions of the fissure and the **pars basalis** behind the anterior ascending limb. That part of this third frontal convolution which borders the fissure of Sylvius is called the **frontal operculum.** The student may have found so great complexity in the arrangement of the fissures and convolutions of the frontal lobes as to have made it difficult for him to recognize these fissures as described. As a matter of fact, while the above-mentioned arrangement is the typical one, each case presents individual variations to such degree as to be at times quite confusing. Small convolutions called **annectant convolutions** or **gyri** not infrequently bridge across fissures, seeming to interrupt them, and connect neighboring convolutions. This arrangement obtains upon other parts of the surface of the brain as well as in the frontal lobe.

The **parietal lobe,** bounded in front by the fissure of Rolando, below by the fissure of Sylvius and behind by the parieto-occipital fissure and a line connecting the latter with the pre-occipital notch, is subdivided by the **intraparietal** or **postcentral fissure** as well as by the terminal portion of the fissure of Sylvius and that of the paralled fissure of the temporal lobe. The **intraparietal fissure,** starting in the lower fore-part of the lobe near the fissure of Sylvius and some little distance behind the fissure of Rolando, passes upward and backward parallel with the latter fissure, curving backward to run almost parallel with the mesial

FIG. 236.—Lateral aspect of left cerebral hemisphere; dorso-median surface is somewhat foreshortened; red lines indicate boundaries separating parietal, temporal and occipital lobes; *r*, Rolandic fissure; *s. g.*, *i. g.*, its superior and inferior genu; S^1, S^2, S^3, S^4 *asc.*, vertical, horizontal, posterior and ascending limbs of Sylvian fissure; *i. p. c.*, *s. p. c.*, inferior and superior precentral; *sf.*, *if.*, superior and inferior frontal; *p. m.*, paramedian; *m. f.*, mid-frontal; *d.*, diagonal, here continuous with inferior precental; p^1, p^2, p^3, p^4, inferior, superior, horizontal and occipital limbs of inter-parietal; *p.-o.*, parieto-occipital; t^1, t^1 *asc.*, superior temporal and its upturned limb; t^2, t^2 *asc.*, middle temporal and its upturned limb; *t. o.*, transverse occipital; *l. o.*, lateral occipital; *A.*, arm centre; *B. T. O.* pars basalis, triangularis and orbitalis; *Arc. p.-o.*, arcus parieto-occipitalis.

border of the hemisphere for a short distance. The vertical part of this sulcus is sometimes broken into an *inferior* and a *superior* part. The horizontal part of the fissure is frequently detached from the vertical part and may be broken up into two sulci, the *ramus horizontalis* and the *ramus occipitalis*, the latter passing uninterruptedly into the occipital lobe. The **postcentral convolution** of the parietal lobe is located behind the fissure of Rolando and in front of the vertical portion of the intraparietal fissure; the **superior parietal lobule** is above the horizontal portion of the intraparietal fissure, while the **inferior parietal lobule** is below it. That part of the inferior parietal lobule which surrounds the upturned end of the fissure of Sylvius is the **supra-marginal gyrus,**

while the portion which surrounds the upturned end of the parallel fissure is the **angular gyrus.** Usually the *first*, *second* and *third annectant gyri* connect the parietal lobe with the occipital.

The **occipital lobe,** separated from the temporal and parietal lobes by the external parieto-occipital fissure and a line connecting it with the pre-occipital notch, is subdivided usually into the **superior** and **inferior occipital convolutions** by two fissures which present considerable irregularity. The upper fissure, the **sulcus occipitalis transversus,** is made up of the two limbs into which the posterior end of the occipital ramus of the intraparietal fissure (p. 506) bifurcates; the lower one, the **sulcus occipitalis lateralis,** is placed between the superior and inferior

FIG. 237.—Island of Reil exposed after cutting away surrounding parts of right cerebral hemisphere.

gyri. Above the transverse occipital fissure and behind and above the occipital ramus of the intraparietal fissure is a small convolution, the **arcus occipitalis,** which connects the occipital and temporal lobes around the end of the parieto-occipital fissure (Fig. 236).

The **temporal lobe,** separated from the frontal and parietal lobes by the fissure of Sylvius and from the occipital by the imaginary line above referred to, is subdivided by two approximately parallel fissures running in a horizontal direction, the **first** or **parallel fissure** and the **second temporal fissure,** into the **superior,** the **middle** and the **inferior temporal convolutions.**

The **island of Reil,** a lobe of the brain located, as previously pointed out, in the fissure of Sylvius, should now be exposed by widely separating the lips of that fissure near the temporal border of the brain. It

may be still better exposed by cutting away the **opercula**—which should be deferred to a later stage—that is, the parts of the frontal, parietal and temporal lobes which abut upon the fissure of Sylvius. The insula will then be seen to be encircled by a groove, the **circular sulcus of Reil.** The **limen insulæ,** situated at the lower fore part of the insula, is a

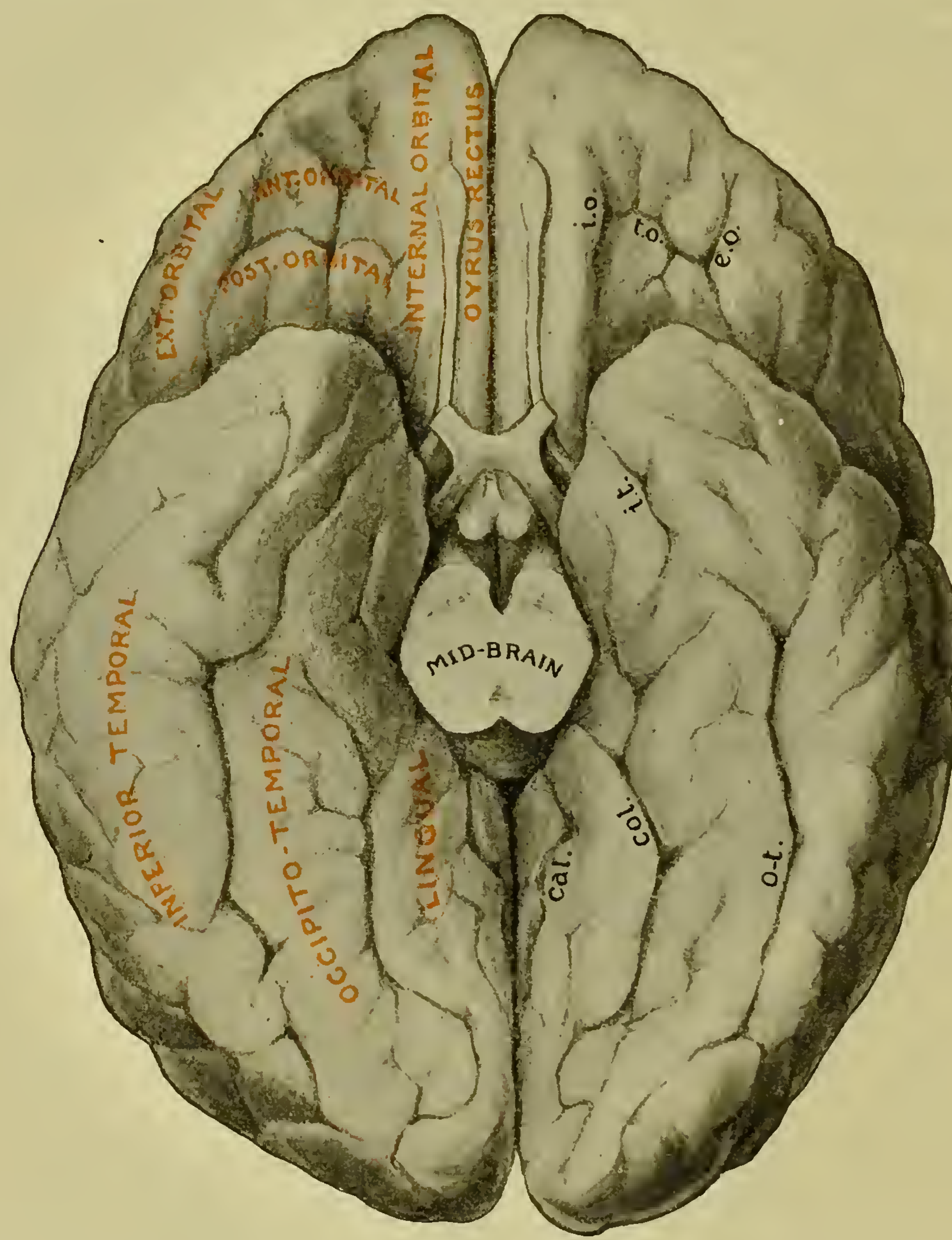

FIG. 238.—Inferior aspect of cerebral hemispheres. *i.o.*, *t.o.*, *e.o.*, internal, transverse and external orbital fissures; *i.t.*, incisura temporalis; *cal.*, calcarine; *col.*, collateral; *o-t.*, occipito-temporal fissures.

small area from which passes upward and backward the **central sulcus of Reil,** dividing the insula into an *anterior* and a *posterior portion.* Each of these parts is subdivided by smaller sulci into a variable number of convolutions. The island belongs to the temporal lobe.

THE INFERIOR SURFACE OF THE HEMISPHERE.—Only the inferior surface of the frontal lobe and a small part of that of the temporal lobe are available for examination at this stage of the dissection. Gently

raising the olfactory bulb and tract, the **olfactory sulcus,** the groove which accommodates these structures, will be exposed. The **gyrus rectus** or **straight gyrus** is that portion of this surface which lies between the sulcus olfactorius and the longitudinal fissure. The back part of the gyrus rectus is delimited from the anterior part by an obliquely directed groove, the portion back of the groove being a part of the **parolfactory area of Broca,** which is situated on the mesial surface of the hemisphere (Fig. 242). The region of the frontal lobe upon the outer side of the olfactory sulcus is subdivided by the **triradiate** or **orbital fissure** (Fig. 238) into the **internal, middle** and **external orbital convolutions.** The orbital sulcus and consequently the gyri are subject to much variation. The gyri are continuous with the superior, middle and inferior frontal convolutions. The **olfactory trigone,** between the diverging roots (*lateral* and *mesial striæ*) of the olfactory tract, is separated by the **sulcus parolfactorius posterior** from the anterior perforated space, which lies behind it. The olfactory bulb, tract, striæ, trigone and the parolfactory area constitute the chief part of the rudimentary olfactory lobe.

The **mesial surface** of the hemisphere can only be studied after separating the two hemispheres from each other. If two brains are available, the separation of the hemispheres may be effected at this stage by passing a long knife down through the great longitudinal fissure and cutting through to the base of the brain; if the dissector has but one brain at his disposal, this plan is not to be followed, the examination of the mesial surface being deferred, in such case, until after the dissection of the right hemisphere (p. 515). For convenience, however, the student may be referred to a picture of such a sagittal section of the brain (Fig. 241) that he may acquire a general idea of the relations of the several parts. On reference to this figure the corpus callosum will be seen occupying a part of this area, while above and below, and in front of and behind the corpus callosum, the free surface of the hemisphere is seen, that is, that part of the surface which in the undisturbed condition looks toward the great longitudinal fissure.

DISSECTION OF THE CEREBRAL HEMISPHERE.

With the brain resting on its base, the top of the right hemisphere may be sliced off by making a cut in the horizontal plane at the level of the calloso-marginal fissure. This may be identified on the mesial surface of the hemisphere as a conspicuous horizontal fissure about midway between the highest part of the corpus callosum and the upper border of the hemisphere, the latter being gently pulled away from its fellow. Instead of using the knife, the fingers may be used to tear off that part of the top of the hemisphere which corresponds to the antero-posterior extent of the corpus callosum. This exposes the central *white*

substance of the hemisphere, the **centrum ovale minus,** made up of nerve-fibres, enclosed by the relatively thin shell of **gray cortical substance.** This section affords opportunity to note the depth of some of the fissures or sulci of the surface of the hemisphere and to note also the way in which the pia mater dips into these sulci (Fig. 239).

The portion of the right hemisphere above the level of the corpus callosum, the callosal convolution, should now be removed, preferably with the fingers, two transverse incisions through this gyrus having first been made opposite, respectively, the anterior and posterior limits of the callosum.

The fibres of the corpus callosum may now be noted passing transversely from that body outward into the substance of the hemisphere and speedily diverging from each other toward all parts of the cortex. If the deep surface of the callosal gyrus just removed be examined, a bundle of longitudinal fibres, the **cingulum,** will be disclosed (p. 550).

THE CORPUS CALLOSUM.—The corpus callosum is made up of a closely compacted group of fibres passing across the mesial plane from one hemisphere to the other, these constituting the great connecting link between the two halves of the cerebrum, the great transverse commissure of the brain. (At a later stage of the dissection it will be seen that there are other collections of fibres, as the anterior commissure, which likewise serve as commissures between the hemispheres.) The sagittal extent of the corpus callosum is seen to correspond with about the middle two fourths of the long axis of the hemisphere (Fig. 239), its dorsal surface forming the bottom of the great longitudinal fissure. Its anterior extremity or **genu** (knee) is traceable downward and backward to terminate in the **rostrum** (Fig. 241), the connection of which latter with the lamina cinerea should be noted. The posterior extremity, more massive than the anterior, is known as the **splenium,** while the **body** is that part which intervenes between the genu and the splenium.

The dorsal surface of the callosum presents a faint longitudinal marking in the mid-line known as the **raphe.** On either side of the raphe are seen the **medial longitudinal striæ** (nerves of Lancisi), while more laterally are the **lateral striæ** or **tæniæ tectæ.** These rudimentary nerve-fibres, in common with the atrophic gray matter (induseum griseum) found here, are atrophic representatives of a part of the limbic lobe, and collectively form the *supracallosal gyrus.* If followed forward the medial striæ are seen to curve round the knee of the corpus callosum to the subcallosal gyrus (Fig. 242), while the lateral striæ, similarly traced, follow outward to the anterior perforated lamina and the parolfactory area (Fig. 242). They are often referred to as the *peduncles* of the corpus callosum. If traced backward, the gray matter

and striæ pass around the posterior extremity of the splenium to the gyrus dentatus, to terminate ultimately at the hook of the uncinate gyrus (Fig. 241).

Those fibres of the corpus callosum that pass through the splenium are known as the **forceps major,** those that pass through the knee being

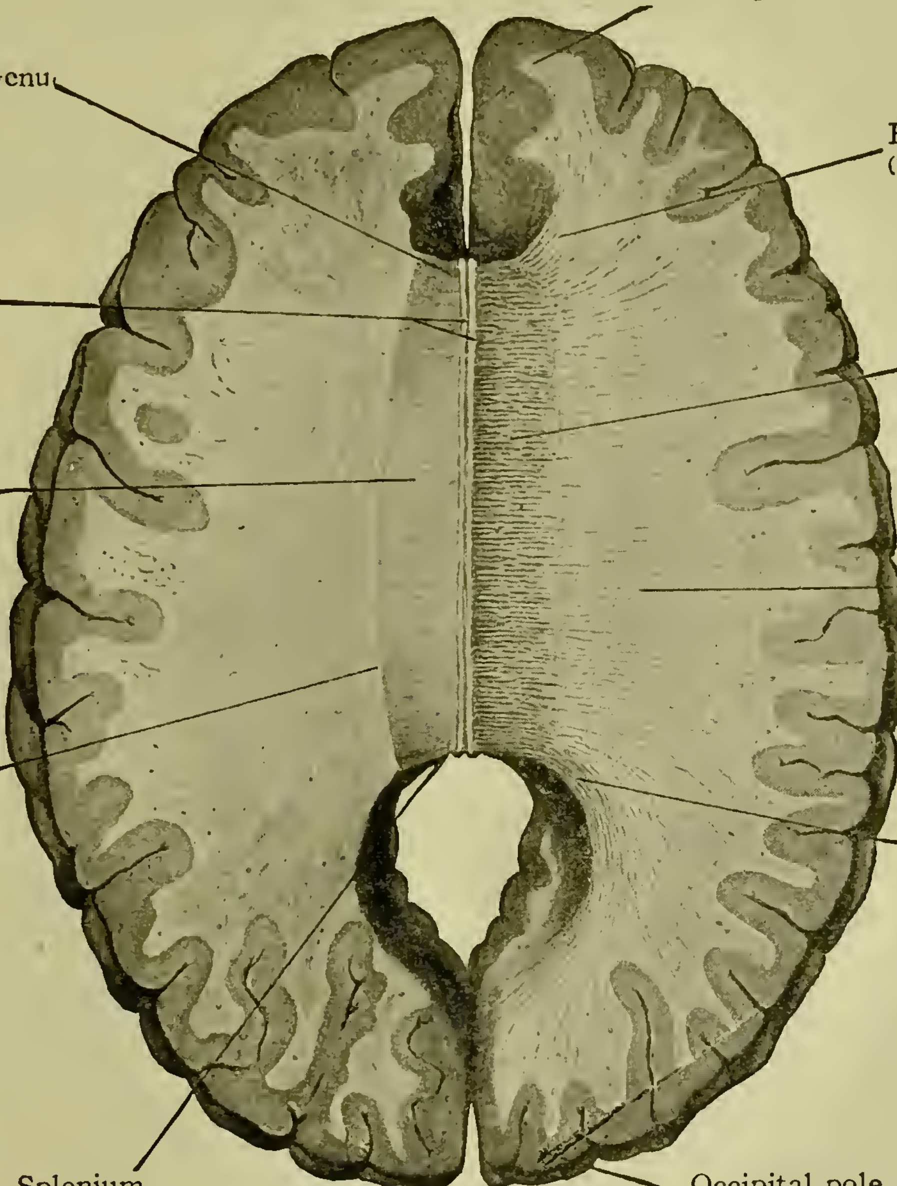

Fig. 239.—Cerebral hemispheres from which upper and median parts have been removed to expose corpus callosum; on left side longitudinal striæ and thin layer of gray matter cover upper surface of corpus callosum; on right side these have been scraped away to expose transverse fibres and anterior and posterior forceps.

designated the **forceps minor,** while the term **tapetum** is variously applied to the lower posterior fibres of the body of the corpus callosum or to other groups of fibres in the body. The course of the fibres of the forceps major should be noted as they sweep posteriorly and somewhat inward toward the occipital pole of the hemisphere, many of them terminating in the cortex on the mesial surface of the occipital lobe.

An incision should now be made parallel with the mesial plane and about one fourth to one half inch to the right of the mid-line of the

corpus callosum in order to sever the fibres which pass into the right hemisphere. The substance upon the right side of this incision should now be cautiously raised, by the handle of a scalpel passed into the incision, in order to expose the cavity of the *lateral ventricle.* As this mass of fibres belonging to the corpus callosum is more and more displaced it will be seen that it bears a very important relation to the lateral ventricle, a relation which will be pointed out more in detail in the succeeding paragraphs.

The right half of the *body of the fornix* is exposed by the removal of the right half of the corpus callosum, this exposed portion of the fornix being seen to be a triangular sheet, the apex of the triangle pointing forward.

The Lateral Ventricle (Fig. 240).—This cavity, contained within the hemisphere of the corresponding side, is the remnant of the cavity of the secondary forebrain vesicle after the walls of the latter have thickened to produce the various parts of the hemisphere. The shape of this cavity roughly follows—at least in horizontal section—the shape of the hemisphere, that is, an **anterior projection** or **cornu** corresponds with the frontal pole of the hemisphere, a **posterior cornu** with the occipital pole and a **lateral** or **descending cornu** with the temporal pole. This cavity has thus far been but partially exposed by the partial removal of the corpus callosum. The exposure of the anterior horn of the ventricle should be effected by removing any portion of white matter still covering it. The posterior horn may be fully exposed by gently tearing away in the upward direction the more posterior fibres of the callosum. To expose the lateral horn, the fibres of the tapetum of the corpus callosum, which cover it above and also form its outer wall as they arch downward toward the base of the hemisphere, should be removed by passing a knife blade carefully into the cavity of the horn of the ventricle and cutting from within outward and upward in such manner as to leave the inner part of the roof of the horn for further study. As the termination of the descending horn of the ventricle is reached in this removal of the fibres, one should stop short of its extreme anterior end in order to preserve the small *amygdaloid nucleus* which lies over the end of the cornu, and in order also not to interfere with the island of Reil.

The cavity of the ventricle will be seen now to consist of a central portion or **body** and of the three extensions mentioned above as the several **horns.** The **anterior horn,** extending forward toward the frontal pole and curving somewhat outward, presents on its outer wall a marked convexity which is the *caudate nucleus* or the *intra-ventricular portion* of the **corpus striatum.** As mentioned previously, the anterior horn is roofed over by the anterior fibres of the corpus callosum. The anterior horn of the ventricle of one side is separated from that of the other by a

vertical layer known as the *septum lucidum* or, more strictly speaking, of two vertical layers which together constitute the septum lucidum (p. 520). The relation of the septum lucidum to the anterior part of the corpus callosum and to the anterior pillar of the fornix is indicated in Fig. 242.

The **body** of the ventricle (pars centralis), likewise roofed over by the fibres of the corpus callosum, is at a higher level than the anterior

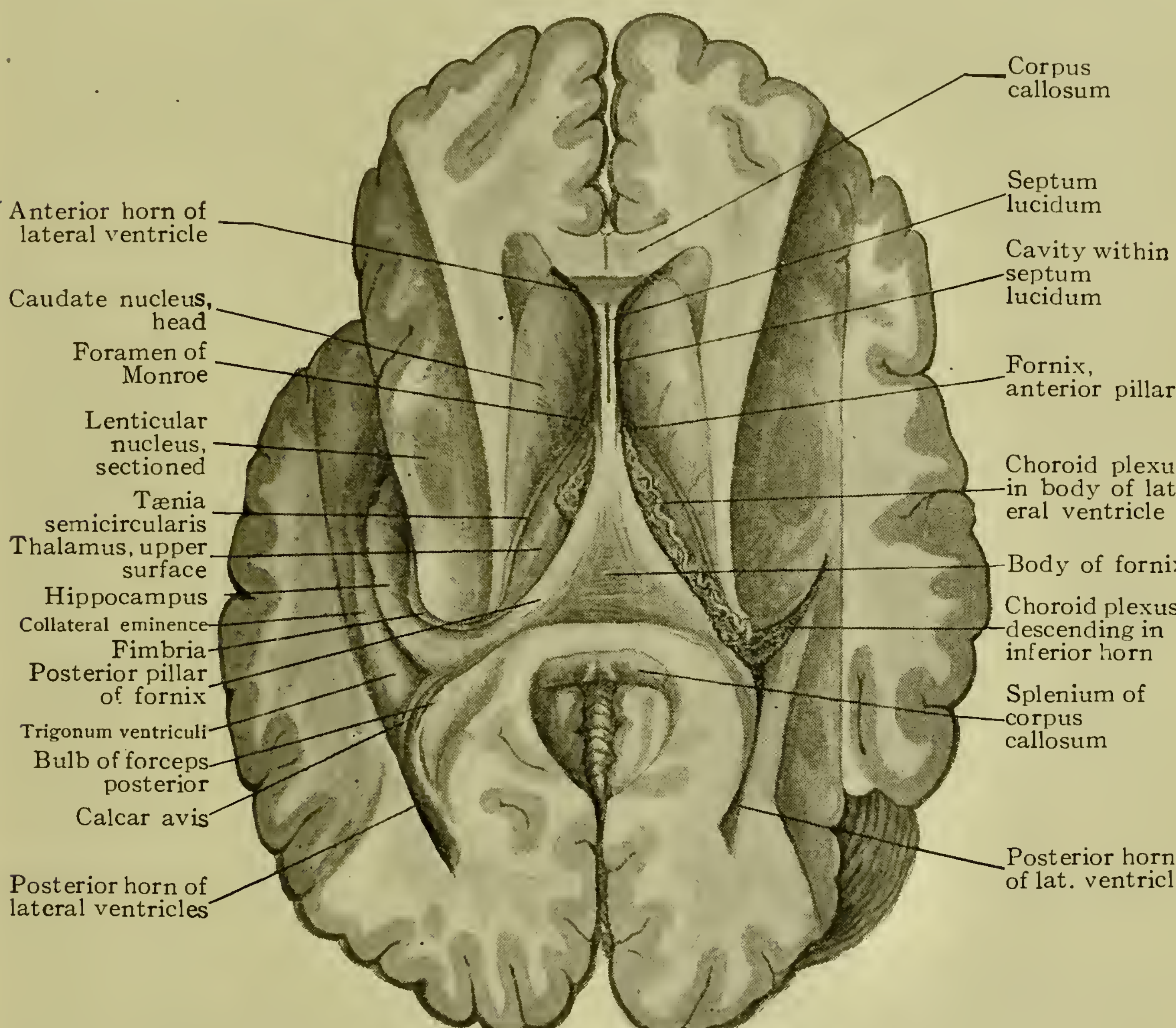

FIG. 240.—Lateral ventricles seen from above after partial removal of corpus callosum and cerebral hemispheres.

horn, and its **floor** presents the following structures from before backward: the *tail of the caudate nucleus*, forming a narrow strip of the floor posteriorly; internal to this, a groove, the **sulcus intermedius,** lodging the *tænia semicircularis* and the *vein of the striate body*; still more internally the *choroid plexus of the lateral ventricle*, a vascular fringe which is the lateral border of the velum interpositum and is richly supplied with blood-vessels; and by the *lateral edge of the body of the fornix* (Fig. 240).

The **tænia semicircularis** is a band of nerve-fibres which arise in the gray matter of the anterior perforated space and in that of the septum

lucidum. If followed backward in the roof of the descending cornu of the lateral ventricle, they are traceable to the amygdaloid nucleus. They are thought to constitute a part of the pathway for olfactory impulses.

The **posterior horn,** passing backward toward the occipital pole and curving somewhat inward, roofed over by the tapetum, presents on the upper part of its mesial wall a prominence, the *bulb*, which is produced by the forceps major of the corpus callosum. Below the bulb, also on the mesial wall, is another projection, the *calcar avis* or *hippocampus minor*, produced by the calcarine fissure on the mesial aspect of the occipital lobe. In the interval between the beginning of the posterior horn and the beginning of the lateral or descending horn is a somewhat triangular area, the *trigone* of the ventricle (Fig. 240).

The **lateral** or **descending horn** of the ventricle, passing at first backward and outward and then downward, forward and inward, terminates near the front of the temporal lobe. A part of its upper wall and its outer wall are constituted by the fibres of the tapetum of the corpus callosum. The remaining part of its upper wall or **roof** is formed by the tail of the caudate nucleus and, at the termination of the horn, by the amygdaloid nucleus. The **choroid plexus of the lateral ventricle** is prolonged from the body of the ventricle into the lateral horn, as is also the lateral edge of the body of the fornix, as the **posterior pillar of the fornix,** which assumes the name of *fimbria* after reaching the lateral cornu. Along the convexity of the fimbria is seen a rounded elevation, the **hippocampus major,** which presents an enlargement, the **pes hippocampi,** at its termination. The hippocampus major is produced by the hippocampal or dentate fissure on the mesial surface of the temporal lobe. The relations of these structures to each other should be carefully noted, that is, the prolongation of the posterior pillar of the fornix along the concavity of the hippocampus major and the prolongation of the choroid plexus along the concavity of the fimbria. On the floor of the descending horn and, therefore, external to the position of the hippocampus major, is another eminence, the **eminentia collateralis,** which is due to the indentation produced by the collateral fissure on the tentorial surface of the hemisphere. The collateral eminence is sometimes divided into an anterior and a posterior part. The lateral ventricle, like the other ventricles of the brain, represents a remnant of the cephalic portion of the neural canal. The lateral ventricle communicates with the third by the **foramen of Monroe** (foramen commune anterius), the aperture of which should be found by the dissector just in front of the optic thalamus near the septum lucidum; into this aperture he should pass a small probe. The choroid plexus of the lateral ventricle is supplied with blood by the anterior choroid artery of the internal carotid, which enters the ventricle at the termination of the descending

horn. The relation of the pia mater to the ventricular wall and the way in which this relation is brought about will be pointed out elsewhere (pp. 520, 522, 550).

The Mesial and Tentorial Surfaces of the Hemisphere.—These aspects of the hemisphere are studied to best advantage when a sagittal mesial section of the brain has been made. In the present instance the part of the right hemisphere allowed to remain in continuity with the left somewhat obscures the view of the mesial surface, but with the aid of Fig. 241 it may nevertheless be studied. The tentorial surface may be examined after the removal of the cerebellum (p. 538). To expose as much of the mesial surface of the left hemisphere as possible, make two transverse vertical sections through what is left of the right hemisphere, one through the frontal lobe just far enough forward to clear the genu of the corpus callosum—the location of which should first be accurately defined—and another through the occipital lobe just back of the descending horn of the lateral ventricle. In removing the cut-off portion of the occipital lobe, do not disturb the pia mater on the mesial surface to any greater extent than necessary and do not injure the cerebellum. After making the section through the frontal lobe, note the manner in which the forceps minor fibres enclose the apex of the anterior cornu of the lateral ventricle as they emerge from the genu.

The dissector should first note the position of the **corpus callosum** (Fig. 241) with its *genu*, *rostrum* and *splenium*, and the relation of the posterior half of the corpus callosum to the upper aspect of the fornix and the optic thalamus, as well as the relation of its anterior half to the *septum lucidum*, which intervenes between it and the anterior part of the fornix.

The **arteries** of the mesial aspect of the left hemisphere (p. 500) should be isolated and identified, after which they should be removed with the pia mater.

The **fissures** found on the mesial surface of the hemisphere are for the most part quite conspicuous. Some of these fissures are designated *total fissures* because of the fact that they so deeply indent the surface as to produce a corresponding prominence on the wall of the ventricular cavity. Fissures which do not thus affect the ventricular wall are known as *partial fissures*. The **total fissures** are the *hippocampal* or *dentate*, the *collateral* and the *anterior portion of the calcarine fissure*.

The **calloso-marginal fissure** (sulcus cinguli) begins beneath the knee of the corpus callosum and passing around the knee and backward parallel with the callosum, turns upward almost at a right angle to its previous course to terminate at or near the upper border of the hemisphere. Not infrequently this fissure is interrupted at a point above about the middle of the corpus callosum. The part, however, beyond the interruption is usually so conspicuous—and this especially

applies to the upturned end—that the student will have little difficulty in recognizing it. The upturned end is the *ramus marginalis*, the upper termination of which is just behind the upper end of the fissure of Rolando. The part of the mesial surface of the hemisphere on the peripheral side of the calloso-marginal fissure is the **marginal convolution**; it is evident that the marginal convolution belongs to the frontal lobe, since it is that part of the hemisphere situated in front of the fissure of Rolando. What appears like an extension of the marginal convolution backward to the ramus marginalis of the calloso-marginal fissure is called the **paracentral lobule,** the back part of which, that is, that situ-

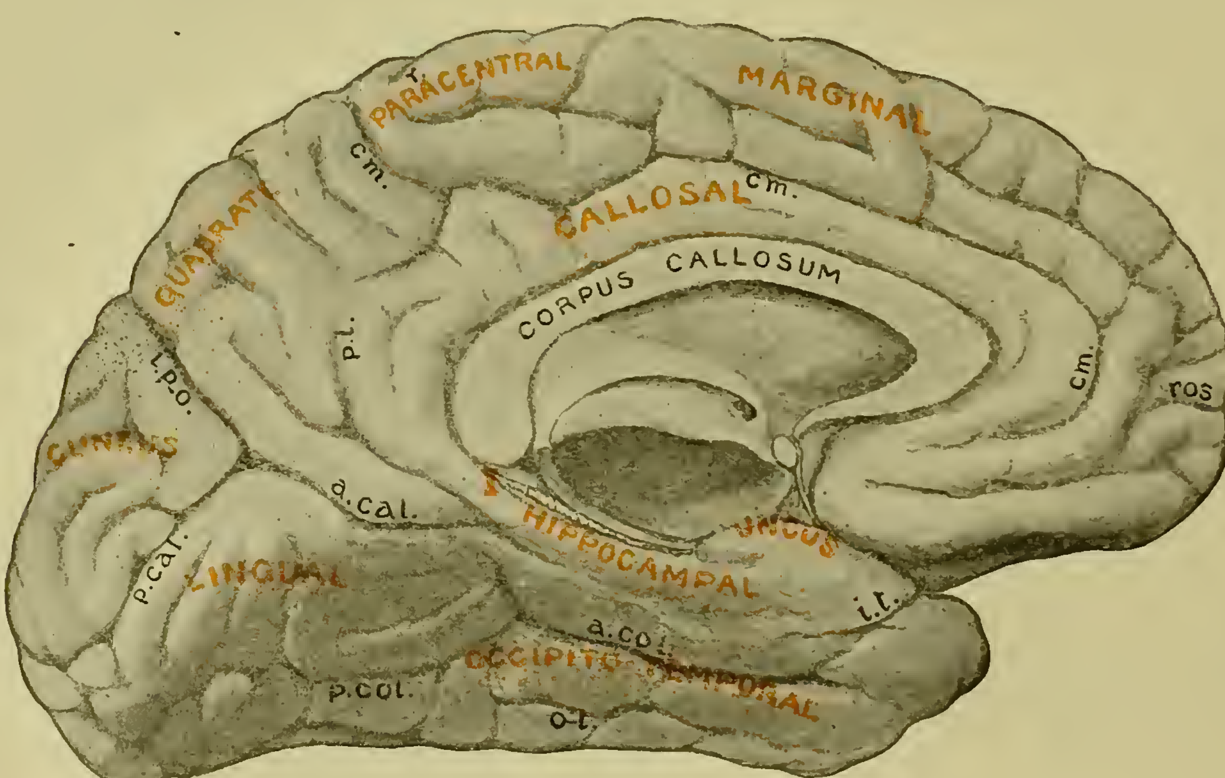

FIG. 241.—Infero-mesial aspect of left cerebral hemisphere; *cm.*, calloso-marginal fissure; *ros.*, rostral; *r.*, overturned end of Rolandic; *p. l.*, post-limbic; *i. p-o.*, internal parieto-occipital; *p. cal.*, *a. cal.*, posterior and anterior calcarine; *p. col.*, *a. col.*, posterior and anterior collateral; *i. t.*, incisura temporalis or rhinial; *o-t.*, occipito-temporal.

ated posterior to the fissure of Rolando, is continuous over the upper border of the hemisphere with the parietal lobe, while the part of the lobule in front of the fissure of Rolando is continuous with the frontal lobe. The lobule is bounded in front by the **paracentral sulcus.**

The **callosal convolution** or **gyrus fornicatus** is that part of the mesial aspect of the hemisphere between the calloso-marginal fissure and the corpus callosum. It extends farther back than the limits of the calloso-marginal fissure and sweeps around the splenium of the callosum to become continuous with a narrow constricted convolution, the **isthmus** (Fig. 241). The callosal convolution is bounded posteriorly by a small, approximately vertical fissure, the **postlimbic sulcus.**

The **internal parieto-occipital fissure,** continuous with the external parieto-occipital fissure already encountered on the lateral aspect of

the hemisphere, passes forward and downward from a point about one half the distance from the upper extremity of the fissure of Rolando to the occipital pole of the hemisphere and is joined at practically a right angle by the **posterior calcarine fissure,** which latter starts from a point quite near the occipital pole. The parieto-occipital fissure is approximately parallel with the ramus marginalis of the calloso-marginal fissure. The **quadrate convolution** or **precuneus** (Fig. 241) lies between these two fissures and is, therefore, since it is in front of the parieto-occipital fissure, a part of the parietal lobe.

The **posterior calcarine fissure,** beginning near the occipital pole and passing upward and forward to join the anterior end of the parieto-occipital fissure, becomes continuous with the **anterior calcarine fissure,** which passes forward and slightly downward to terminate at the back part of the hippocampal convolution. The anterior calcarine fissure is a total fissure, since it indents the posterior horn of the lateral ventricle to produce the calcar avis or hippocampus minor on its inner wall (Fig. 240).

The **cuneus** is a wedge-shaped convolution of the occipital lobe bounded in front and above by the parieto-occipital fissure and in front and below by the posterior calcarine fissure.

The **hippocampal** or **dentate fissure** extends from a point just below the splenium of the corpus callosum downward and forward toward the position of the anterior perforated space. This is one of the total fissures, since it produces on the mesial wall of the descending horn of the lateral ventricle the prominence of the hippocampus major.

The **dentate convolution** or **gyrus dentatus** is a small mass of gray matter situated within the hippocampal fissure. This relation is more fully explained on page 550.

The **posterior collateral fissure,** starting upon the tentorial surface of the occipital lobe (Fig. 241), passes forward somewhat irregularly to become continuous usually with the **anterior collateral fissure,** which is situated on the tentorial aspect of the temporal lobe below and approximately parallel with the hippocampal fissure. The anterior collateral fissure is a total fissure, since it indents the floor of the descending horn of the lateral ventricle to produce there the collateral eminence.

The **hippocampal convolution** or **gyrus uncinatus** is situated between the hippocampal fissure and the anterior collateral fissure. At the anterior termination of the hippocampal fissure the hippocampal convolution hooks round the fissure constituting its **uncus** or **hook.** Posteriorly the hippocampal convolution is continuous with the constricted convolution mentioned above as the isthmus, and through the isthmus becomes continuous with the callosal convolution. If the student will inspect Fig. 241 or his dissection he will note that the callosal convolution, the isthmus and the hippocampal convolution form a ring-like

lobe, the **limbic lobe,** surrounding the corpus callosum and the position of the optic thalamus, the ring, however, being incomplete in front where the beginning of the fissure of Sylvius interrupts it. The anterior portion of the hippocampal convolution is marked off from the apex of temporal lobe by a small, irregular fissure, the **incisura temporalis** or **rhinial fissure.**

The **inferior temporal** or **occipito=temporal sulcus,** beginning on the tentorial surface of the occipital lobe, passes forward to the inferior aspect of the temporal lobe approximately parallel with the collateral fissure.

The **lobulus lingualis** is an elongated convolution belonging partly to the tentorial and mesial surfaces of the occipital lobe, where it lies below the calcarine fissure and above the posterior collateral fissure, and partly to the mesial surface of the temporal lobe, where it joins the hippocampal convolution (Fig. 241).

The **occipito=temporal gyrus** is an elongated convolution also belonging partly to the tentorial surface of the occipital lobe and partly to the inferior surface of the temporal lobe, lying between the collateral and the occipito-temporal fissures (Fig. 238).

The **subcallosal gyrus** is a quite small convolution lying below the knee of the corpus callosum to be brought into view by partially displacing the front part of the callosal convolution from the corpus callosum (Fig. 242); the **supracallosal gyrus** (p. 510) lies above the corpus callosum; both are atrophic parts of the limbic lobe.

The top of the left hemisphere should now be sliced off level with the upper surface of the corpus callosum by using a long knife and entering it at the anterior margin of the hemisphere at the level indicated, and carrying it backward toward the occipital region with one sweep. The sliced-off top of the hemisphere should be preserved that it may be replaced when the two hemispheres shall have been entirely separated. A longitudinal incision should be made along the left side of the mid-line of the corpus callosum, care being exercised not to cut too deeply and stopping short of the forceps major. The part of the corpus callosum to the left of this incision may then be raised by the handle of the scalpel and gently torn away, exposing the cavity of the lateral ventricle. The mesial portion of the corpus callosum should now be elevated carefully by insinuating some flat object, as the handle of a scalpel, beneath it, and it may then be completely removed by the necessary incisions, one just back of the genu and one just in front of the splenium, its attachment in the mid-line to the body of the fornix being noted. This exposes the body of the fornix (Fig. 240).

The Fornix.—The fornix consists of a triangular *body*, *two anterior crura* or *pillars* and *two posterior crura or pillars.* The **body** of the fornix, in relation by its upper surface with the corpus callosum and by its

under surface with the velum interpositum, the edges of which latter, as the choroid plexuses project into the floor of the respective lateral ventricles, is wide behind and tapers anteriorly where it divides into the two anterior pillars. Raise and gently pull the choroid plexus outward and note the thin membrane, the epithelial lining of the ventricle, the **ependyma,** passing over the fornix and the plexus.

The **anterior pillars** of the fornix diverge from each other as they pass downward and forward in front of the optic thalamus of the corresponding side, and finally reach the base of the brain, where each one acquires connection with the corpus albicans of its own side. From the nucleus of the corpus albicans these fibres curve backward and upward to terminate in the anterior nucleus of the optic thalamus as the bundle of Vicq d'Azyr. The anterior pillars are in relation by their anterior

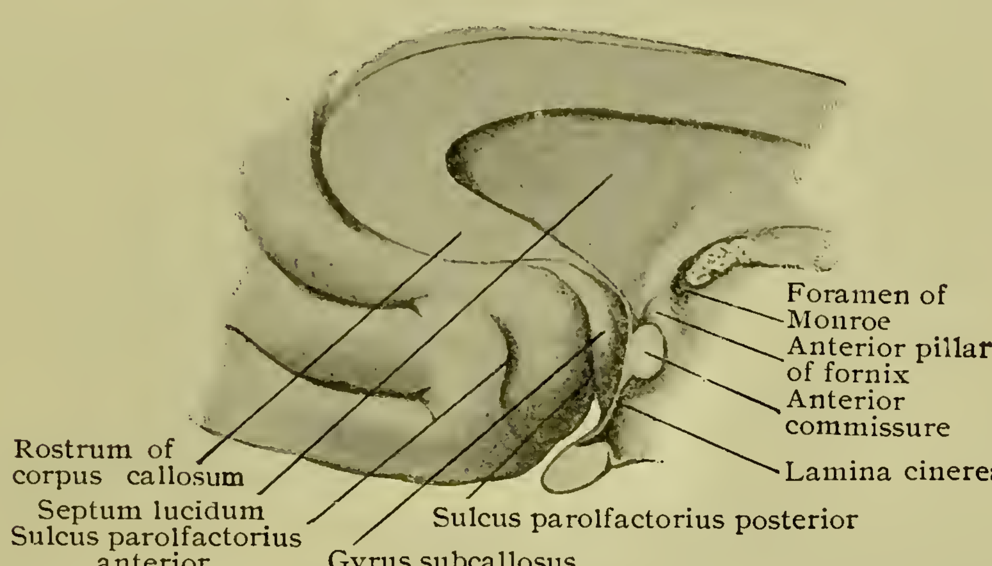

FIG. 242.—Portion of mesial surface of right hemisphere, showing gyrus subcallosus and parolfactory area, the latter lying between the anterior and the posterior parolfactory sulcus.

surface with the *anterior commissure* (Fig. 242), a band of fibres connecting the anterior part of one temporal lobe with the corresponding part of the opposite temporal lobe. Behind the descending anterior pillar is a space, between it and the anterior surface of the optic thalamus; this is the **foramen of Monroe** through which the third ventricle communicates with the lateral ventricle. The foramen of Monroe transmits the choroid plexus, that is, the choroid plexus of one lateral ventricle becomes continuous through the foramen of Monroe with that of the other and with the choroid plexuses of the third ventricle. The foramen of Monroe will be easily located if the dissector will gently raise the choroid plexus of the lateral ventricle of either side and follow it forward and downward to the point where it passes through this aperture; the latter may be still further demonstrated by passing a small probe through it into the third ventricle. Since there are two lateral ventricles and one third ventricle, the foramen of Monroe has a single opening into the third ventricle, which opening or canal bifurcates into two lateral arms,

one for each lateral ventricle. The anterior pillar should be carefully raised to the extent of about one sixteenth of an inch, when the dissector will be able to demonstrate that it is joined by a narrow, white band, the tænæ semicircularis or stria terminalis, encountered in the study of the lateral ventricle as lying in the groove between the optic thalamus and the caudate nucleus (p. 513).

The **posterior pillars** of the fornix are the continuations of the lateral borders of its body and, as already noted, are prolonged, in reduced form and under the name of the **fimbriæ,** into the descending horns of the lateral ventricles in the concavity of the hippocampus major (Fig. 240). The fibres of the posterior pillars traced into the descending horn are found to be connected with the hippocampus major, some of the fibres passing to the *alveus* and others to the uncinate portion of the hippocampal convolution.

The fornix, including both its body and the anterior and posterior pillars, is made up chiefly of *longitudinal fibres* which are connected with certain parts of the olfactory centres. If the fornix now be incised at the anterior part of its body and the latter be turned backward, a *transverse striation*, the *lyra* or *psalterium*, may be seen on its under surface, this being due to the fact that some of the fibres of the posterior pillars cross from one side to the other at this place and so connect the cornu Ammonis of one side with that of the other (Fig. 244).

The fornix may perhaps best be understood if one thinks of it as the mesial border of the white substance of one hemisphere united with the corresponding mesial border of the white substance of the other hemisphere throughout that region which we recognize in the adult brain as the body of the fornix, the posterior crura representing parts of this mesial border which have remained sufficiently far from the mesial plane to have remained isolated. A cross-section through the hemisphere in such position as to strike the anterior part of the descending horn of the lateral ventricle (Fig. 243) shows the cortical gray matter apparently folded upon itself in the hippocampal fissure to constitute the gyrus dentatus. The underlying white medullary matter continued beyond the site of the gyrus dentatus is left exposed by the cessation of the gray cortical matter at the latter point, and this exposed white border is the structure we recognize as the fimbria of the fornix. The pia mater in the form of a richly vascular fold invaginates the thin epithelial wall of the ventricle upon the mesial side of the fimbria and so apparently comes to lie within the ventricular cavity, but since it pushes the epithelium (ependyma) before it, it is in reality excluded thereby from the cavity of the ventricle (pp. 522 and 550).

The Septum Lucidum (septum pellucidum).—This structure has been referred to as consisting of two circumscribed portions of the mesial walls of the hemispheres brought into close relation with each other—

circumscribed by the growing through from one hemisphere to the other of the corpus callosum, above and in front of the fornix (Fig. 246). Hence of the two thin laminæ of which the septum lucidum is composed, each one represents a part of the mesial wall of the corresponding hemisphere. If the dissector will now examine the upper part of the septum lucidum in the dissection as it intervenes between the anterior parts of the lateral ventricles, he will be able to demonstrate the two thin layers, which with care he may separate from each other. The cavity between the laminæ is often called the **fifth ventricle,** an erroneous term, however, since the name *ventricle* is appled to some part of the persisting cavity of the neural tube, whereas the cavity of the septum lucidum is simply a

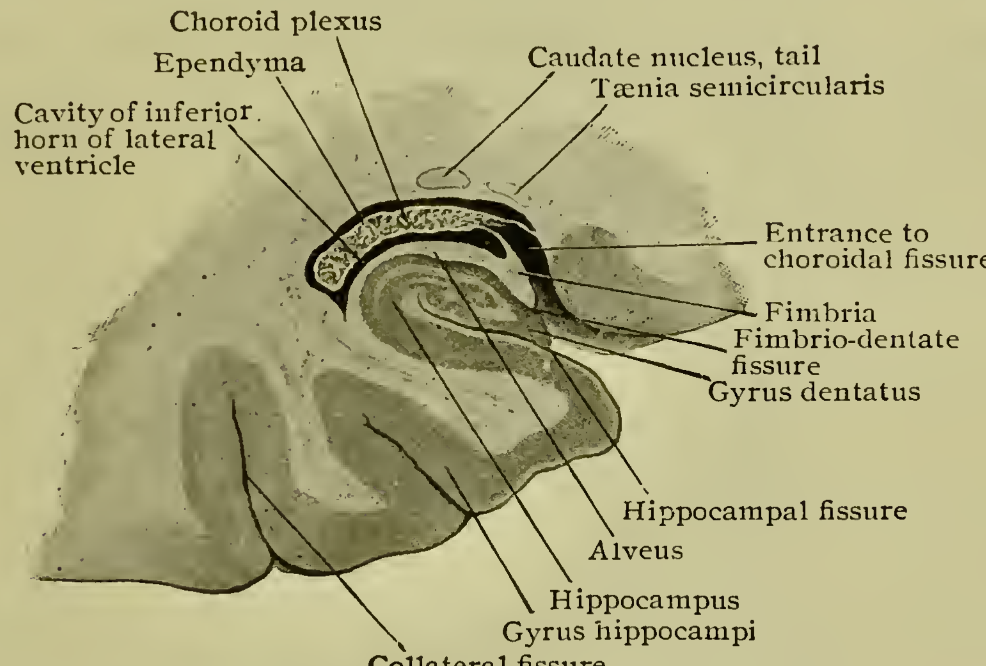

FIG. 243.—Frontal section of part of left hemisphere passing through lower end of inferior horn of lateral ventricle. ×2.

shut-off portion of the great longitudinal fissure which has been isolated by the growing through of the callosum.

The remaining parts of the telencephalon must be examined at a later stage of the dissection (p. 528).

THE DIENCEPHALON.

The part of the brain known as the diencephalon or *inter-brain* is now exposed from above, although laterally it is still in relation with parts of the cerebral hemispheres. It consists of the structures developed from what is left of the primary fore-brain vesicle after the outgrowth from the latter of the secondary fore-brain vesicles to produce the hemispheres. The diencephalon in its early condition is a simple, unpaired vesicle or sac, the lateral walls of which thicken greatly to produce in each case a large ovoid mass known as the *optic thalamus.* These two masses in the mature condition are placed side by side near the base of

the brain, the space between them being about one sixth to one fourth of an inch in its transverse diameter; this space, the adult *third ventricle*, represents what is left of the cavity of the diencephalon. The dorsal wall of the vesicle remains extremely thin and becomes intimately related with the overlying layer of pia mater, which layer, upon the coming together of the dorsal wall of the vesicle and the under surface of the developing hemispheres (pallium), is brought into contact with the layer of pia mater on the latter surface, thus forming the *velum interpositum;* this structure the dissector now finds exposed upon reflecting the triangular body of the fornix (Fig. 244).

The velum interpositum then consists of two layers of pia mater united with the thin epithelial roof or dorsal wall of the diencephalon: It is triangular in shape; its lateral borders are extremely vascular and present a fluffy appearance, these vascularized edges of the structure being known as the **choroid plexuses of the lateral ventricles.** Since the velum is larger than the body of the fornix, the choroid plexus of each side projects beyond the edge of the fornix into the ventricular cavity. The dissector has already traced the choroid plexuses into the descending horns of the lateral ventricles and has also seen that anteriorly the choroid plexus of each side passes through the foramen of Monroe. If the velum be gently elevated at its posterior border by grasping it with the forceps, it will be seen to be continuous beneath the forceps major with the layer of pia mater upon the upper surface of the cerebellum, as well as with a layer of the pia which is continued to the tentorial surface of the hemisphere. If now the mesial part of what remains of the posterior part of the right hemisphere be slightly elevated, the pia mater which is continuous with the velum will be seen to pass apparently through the mesial wall of the hemisphere, but in reality through the hippocampal fissure, into the descending horn of the lateral ventricle. (Compare p. 520.)

The **transverse fissure of the brain,** the **fissure of Bichat,** is the space which is occupied by the velum interpositum and its prolongations into the descending horns of the lateral ventricles. Hence this transverse fissure has the shape of a horse-shoe, the central segment of the shoe corresponding to the back part of the roof of the third ventricle, while its lateral portions, inclined at an angle, represent the line of invagination of the pia into the descending horn.

The **vein of the choroid plexus** unites near the anterior angle of the velum with the **vein of the corpus striatum** to form the **vein of Galen,** the latter passing backward, near the mid-line of the velum, to emerge with its fellow through the transverse fissure of the brain. The two venæ Galeni unite with the inferior longitudinal sinus to form the straight sinus (p. 327). The **posterior choroid artery,** a branch of the posterior cerebral, passes inward through the transverse fissure to supply

the choroid plexus of the third ventricle. The **anterior choroid artery,** a branch of the internal carotid, supplies the choroid plexus of the lateral ventricle, passing into the descending horn of that cavity near its termination (Fig. 235).

The splenium should now be cut on either side near the border of the velum and should be removed by gently detaching it from the subjacent pia mater.

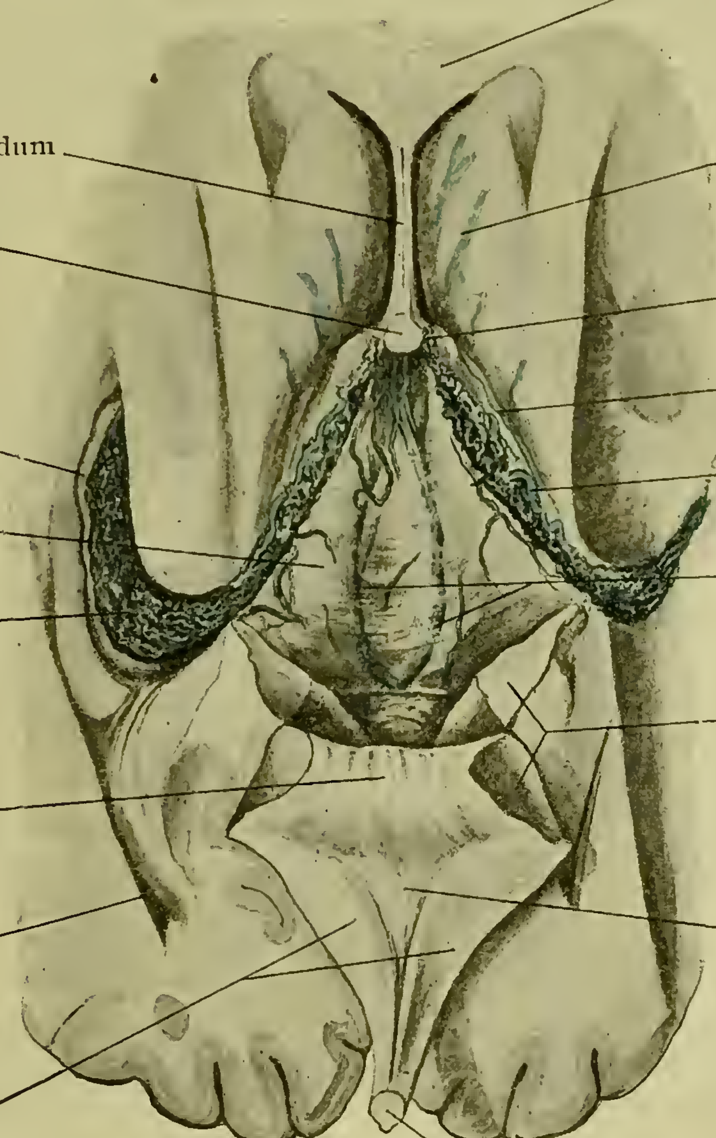

FIG. 244.—Dissection of brain, showing velum interpositum and choroid plexuses of lateral ventricles, seen from above after removal of corpus callosum and fornix; latter has been cut through in front and behind and turned back, exposing its under surface.

The velum may now be incised near its anterior angle by a transverse cut and gently elevated and turned backward, when it will be noted that its lateral borders are loosely attached to the upper surfaces of the optic thalami. The **choroid plexuses of the third ventricle** will be seen on the under surface of the velum close to the mid-line and parallel with each other.

The **pineal body** or so-called pineal gland (conarium, epiphysis cerebri) will be exposed by reflecting the velum well back beyond the limits

of the third ventricle. The pineal body, like the velum, belongs to the roof or dorsal wall of the diencephalon. The base of the pineal body is attached to a transverse band, the *habenular commissure*, from which its peduncles pass forward as the **striæ medullares,** one on the upper border of the mesial surface of each optic thalamus.

The Optic Thalamus.—The **upper surface** of the optic thalamus presents a groove passing forward and inward (Fig. 245), which represents the line of attachment of the choroid plexus. On the mesial side of this groove, near its posterior extremity, is a depressed area, the **habenula,** within which is contained a collection of nerve-cells,

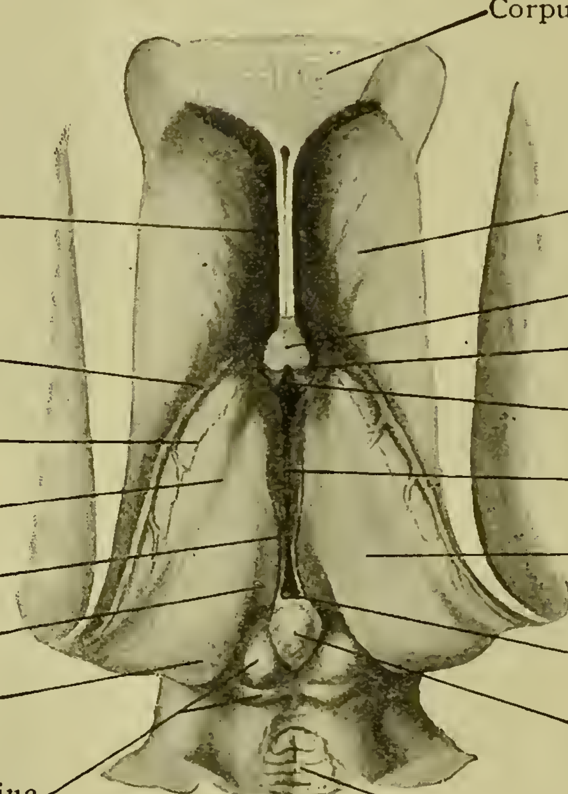

FIG. 245.—Thalami, caudate nuclei and ventricles viewed from above after removal of corpus callosum, fornix and velum interpositum; third ventricle shows as narrow cleft between mesial surfaces of thalami.

the **ganglion habenulæ.** That portion of the dorsal surface of the thalamus which is lateral to the oblique groove helps to form the floor of the lateral ventricle.

The **mesial surface** of the thalamus, forming the lateral wall of the third ventricle, presents near its upper limit the **tænia thalami,** a band of thickened ependyma which overlies the **stria medullaris** or prolongation of the pineal pedicle, and the attachment about its middle of the **middle** or **soft gray commissure** of the third ventricle (Fig. 246).

The **outer surface of the thalamus,** as previously pointed out, looks toward the internal capsule and is not a free surface as are the dorsal and mesial surfaces. The entire outer surface of the thalamus presents fibres which emerge from it as its *outer peduncle*, the more posterior

part of this group being designated the **optic radiation,** since it is made up of fibres having to do with the optic nerve nuclei and which are encountered in the posterior third of the posterior segment of the internal capsule on their way to the cortical centres of vision.

The **inferior surface** is likewise not a free surface but comes into relation with what is known as the **subthalamic tegmental region,** the prolongation of the tegmental part of the mid-brain, which can only be studied satisfactorily in coronal sections of the brain. It may simply be stated here that many fibres emerge from and enter the inferior surface of the thalamus, constituting its **inferior peduncle.** Similarly fibres emerge from the anterior extremity of the thalamus, constituting its

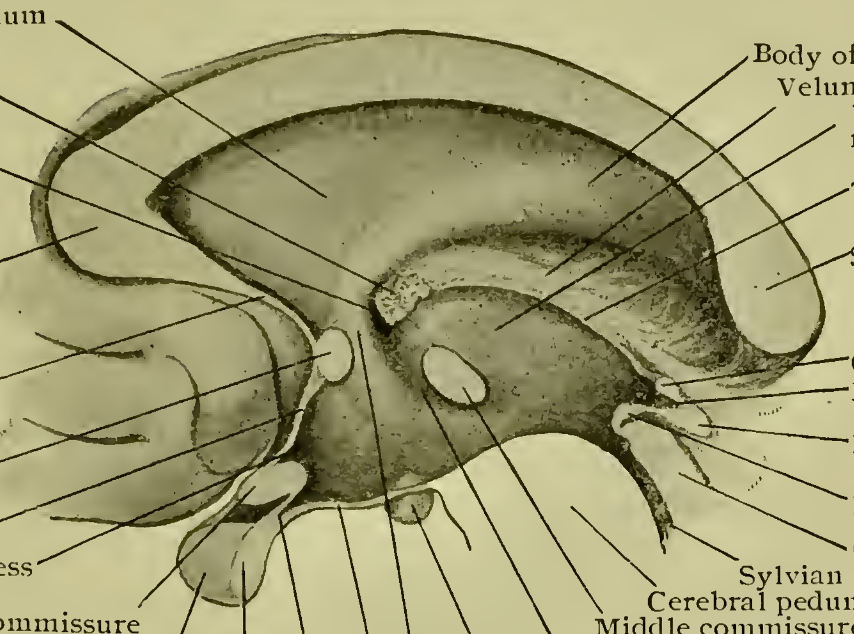

FIG. 246.—Right lateral wall of third ventricle; velum interpositum covers superior surface of thalamus.

anterior peduncle, these being the fibres found in the anterior segment of the internal capsule as the *thalamo-frontal fibres.*

The **posterior extremity of the thalamus** presents an enlargement, the **pulvinar,** which projects somewhat outward as well as backward. The thalamus is composed not of a single mass of gray matter, but of three such masses—the **anterior nucleus,** forming a part of the anterior projection; the **external nucleus,** which includes the pulvinar; and the **mesial nucleus,** which latter is continuous with its fellow of the other side by means of the middle commissure already referred to.

The Third Ventricle.—The third ventricle, exposed by the removal of the velum, is a cavity quite narrow transversely, but of considerably greater extent in the vertical and antero-posterior directions. Its **roof** (p. 522) and **lateral walls** (p. 524) have been sufficiently indicated. Its **floor** is made up of those structures developed from the ventral wall of

the diencephalon which occupy the interpeduncular space at the base of the brain, that is, the posterior perforated space, the corpora albicantia and the tuber cinereum with its infundibulum and pituitary body (Fig. 246). At the posterior limit of the cavity is seen the anterior orifice of the **aqueduct of Sylvius** leading backward to the fourth ventricle. Above this orifice is a transverse band, the **posterior commissure,** which, however, is not a true commissure, but a place of decussation of certain fibres, as of the posterior longitudinal fasciculus and the fillet. The middle commissure has been already mentioned as consisting of gray matter; it is therefore called the *soft commissure.* The **anterior commissure** (p. 550) is at the anterior limit of the cavity in front of the anterior pillars of the fornix, and assists the latter and the lamina cinerea to form its **anterior wall.** The aperture of the foramen of Monroe will also be found at the anterior wall of the ventricle.

The pulvinar of the thalamus and the median and lateral geniculate bodies also belong to the diencephalon, but will be dissected with the mid-brain.

THE MID-BRAIN.

The mid-brain or mesencephalon includes the parts surrounding the aqueduct of Sylvius or the parts developed from the mid-brain vesicle. The latter, by the thickening of its dorsal wall, gives rise to the **lamina quadrigemina** upon which rest the **corpora quadrigemina;** by the thickening of its lateral walls it produces the **superior peduncles of the cerebellum** in part; by the thickening of its ventral walls it gives rise to the **crura** or **peduncles of the cerebrum.** To expose these parts (Fig. 247) gently tear away, using the knife or scissors when necessary, the right fimbria and posterior pillar of the fornix with the related choroid plexus and hippocampus major throughout their extent to the end of the inferior cornu of the lateral ventricle. This frees the posterior pole of the thalamus. The dorsal surface of the mid-brain now exposed presents four small elevations, an anterior pair considerably larger than the posterior pair, called collectively the **corpora quadrigemina.** The pineal body usually rests upon the groove between the two anterior quadrigeminal bodies and may be displaced forward. The **anterior quadrigeminal bodies,** the **colliculi superiores** (nates), are each continuous with a little band, the **superior brachium,** which passes forward and outward between the thalamus and the median geniculate body to disappear beneath a small eminence, the **external** or **lateral geniculate body.** The anterior quadrigeminal bodies are directly connected with the optic mechanism, some of the fibres of the optic tract passing into the bodies to arborize around the cells of their gray matter, while from these cells axones pass to the centre for vision in the cortex of the cerebrum.

Inverting the brain, the optic tract of the right side should be followed backward from the optic chiasm across the ventral surface of the crus and traced, its *lateral* or *visual portion* to the pulvinar of the thalamus, to the external geniculate body, and through the **anterior** or **superior brachium** to the anterior quadrigeminal body.

To summarize, then, the fibres of the optic tract, with an unimportant exception, are the axones of the ganglion cells of the retina and pass, some of them, to the pulvinar of the thalamus, some to the external geniculate body and some to the anterior quadrigeminal body, from which relay stations new axones pass to the cortex of the brain by way of the optic radiations and the posterior third of the posterior segment of the internal capsule. The importance of the anterior quadrigeminal

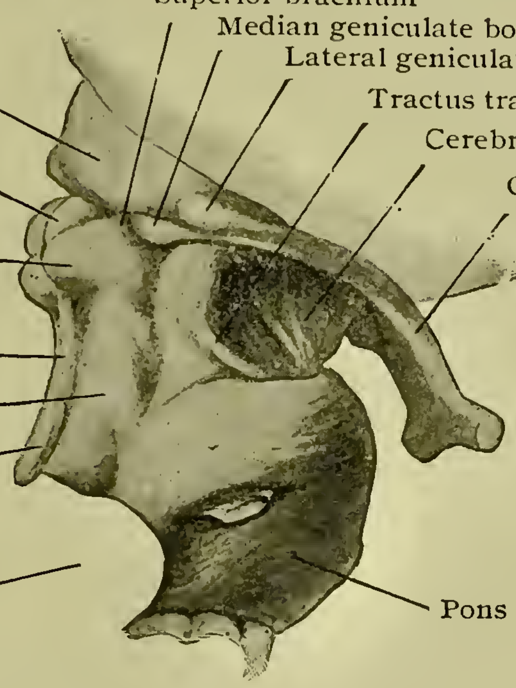

FIG. 247.—Dorso-lateral aspect of mid-brain.

bodies to the visual function is exemplified by their relatively large size in birds where they constitute the *optic lobes*.

The **posterior quadrigeminal bodies** or **colliculi inferiores,** considerably smaller than the anterior, are separated from the latter by a transverse groove and from each other by a longitudinal groove. Each posterior body is continued in the form of a narrow strand of fibres, the **inferior brachium,** into and upon the little body known as the **internal** or **median geniculate body** which lies under cover of the pulvinar of the thalamus. From the internal geniculate body fibres pass to the *mesial portion* of the optic tract. These fibres, though contained within the optic tract, have nothing to do with the optic apparatus, but constitute **Gudden's commissure.** The posterior quadrigeminal bodies, constituting a part of the auditory apparatus (p. 547), are found only in those osmatic mammals that are provided with a spirally wound cochlea.

Like the anterior quadrigeminal bodies, the posterior bodies contain gray matter in their interior, that is, nerve-cells, which gray matter is overlaid by a thin layer of white matter, the stratum zonale.

The **superior peduncles of the cerebellum** appear as two rounded bands on the dorso-lateral surface of the mid-brain back of the position of the quadrigeminal bodies. They converge as they approach these bodies and sink from view beneath the posterior quadrigeminal bodies. Traced backward, they diverge along the lateral walls of the anterior half of the fourth ventricle and pass into the cerebellum. They will be mentioned in studying the cross section of the mid-brain.

The **crura cerebri** (Figs. 166 and 254), on the ventral aspect of the mid-brain, appear as rounded masses at their points of emergence from the upper border of the pons, diverging as they pass forward and upward to enter the bases of the hemispheres immediately to the outer side of the optic thalamus of the corresponding side. Each crus is crossed near its attachment to the hemisphere by the optic tract and farther backward by the small fourth cranial nerve, which the student should identify as this nerve passes from its superficial origin on the dorsal surface of the valve (p. 502) to reach the ventral aspect of the crus. The space between the two diverging crura is the **interpeduncular space,** at the apex of which—that is, at the upper border of the pons—the third nerves have their superficial origin. The structures contained within the interpeduncular space have been enumerated (p. 526).

The **aqueduct of Sylvius,** which traverses the mid-brain, connecting the fourth ventricle with the third, may be demonstrated by passing a small probe into its anterior orifice backward to its posterior orifice at the apex of the fourth ventricle.

A study of the transverse section of the mid-brain, necessary for the appreciation of the arrangement of its constituent parts, will be undertaken at a later stage of the work (p. 547).

Having completed the examination of the surface of the mid-brain, the superficial transverse fibres on the ventral surface of the pons may be removed on the right side by cautiously tearing them from the underlying longitudinal fibres after having made a superficial longitudinal incision on the right side of the mid-line. This exposes the longitudinal fibres of the pons and enables one to observe their continuity below with the pyramids of the medulla and above with the ventral parts of the crura cerebri and to follow the latter into the under surface of the cerebral hemisphere. The mid-brain should now be cut transversely, the knife being entered between the anterior and posterior quadrigeminal bodies. The examination of the cerebral hemispheres may now be completed.

The Corpus Striatum.—This is a large mass of nerve-cells with inter-penetrating nerve-fibres found near the base of the hemisphere

and not far from the mesial plane. If the student will conceive of the secondary fore-brain vesicle as presenting a localized thickening in the early stages of its development on its ventro-lateral aspect, this localized thickening being brought about by rapid multiplication of cells and corresponding in position in a general way to that portion of the ventro-

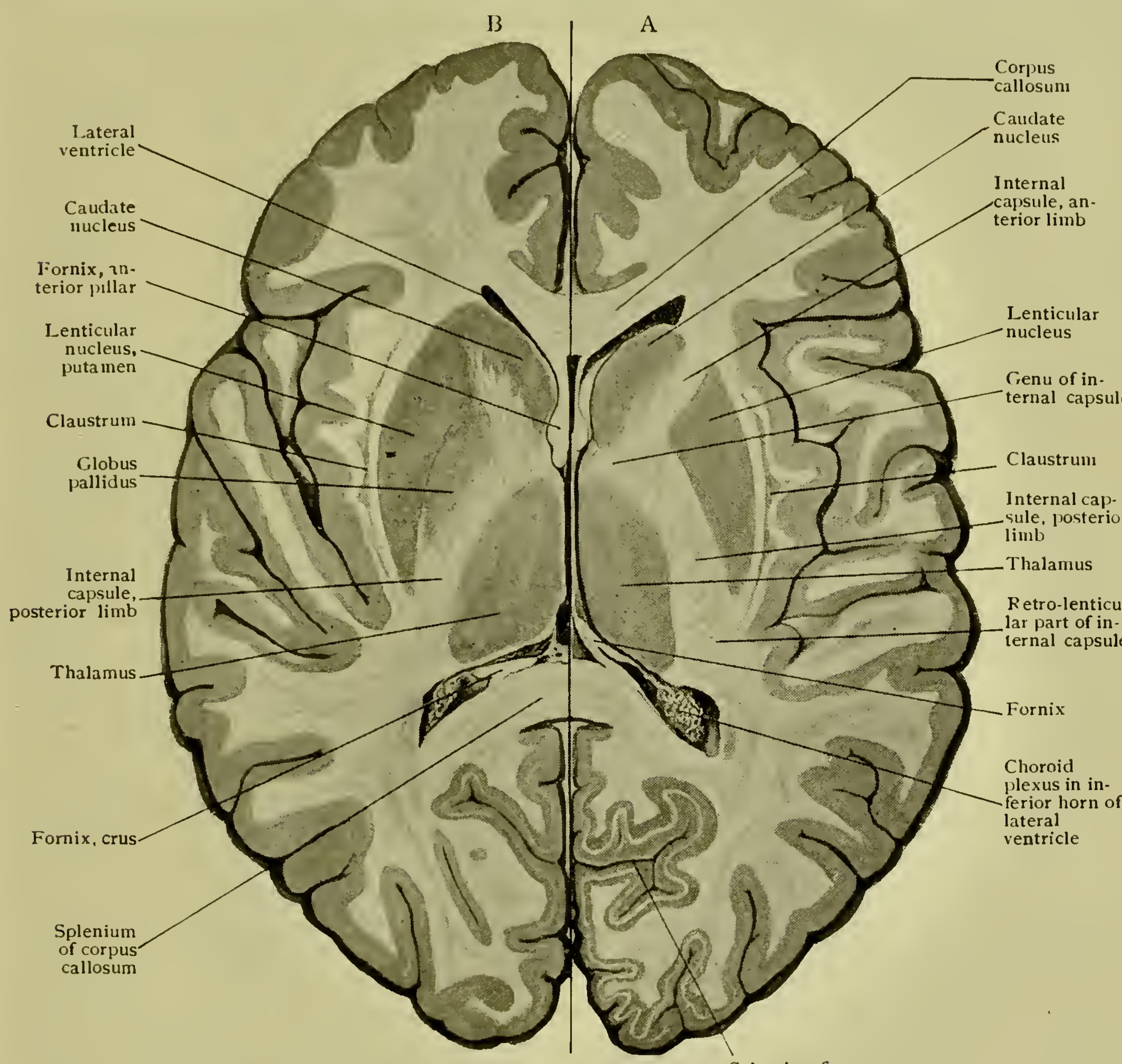

FIG. 248.—Horizontal sections of brain, A at higher level than B, which passes through lower part of corpus striatum where caudate and lenticular nuclei are continuous; relations of limbs of internal capsule to internal nuclei seen on right side.

lateral aspect of the vesicle which shows a depression, the fossa of Sylvius, the site of the island of Reil and the beginning of the fissure of Sylvius, he will have a conception of the nature of the corpus striatum and of its relation to the cortex of the adult hemisphere. The outgrowth of the axones of the cells composing this mass and the penetration into it by processes of cells at distant points, which processes are to acquire physiologic connection with the cells of the corpus striatum, account for the breaking up of the mass into several segments by bands

of nerve-fibres. The corpus striatum is primarily divided into two portions, the *nucleus caudatus*, called from its relation to the lateral ventricle the *intra-ventricular part*, and the *nucleus lenticularis* or the *extra-ventricular part*, situated to the outer side of the caudate nucleus (Fig. 240). These two are separated from each other by a band of fibres known as the *internal capsule*, except at their fore part, where they are in direct continuity with each other; they are likewise connected at intervals by bands which intersect the fibres of the internal capsule.

The **caudate nucleus** forms an irregularly ovoid mass which encroaches upon the cavity of the lateral ventricle as noted above, the caudal projection or *tail* of which passes backward, helping to form the floor of the body of the lateral ventricle (Fig. 240); then curving downward, outward and forward it helps to form the roof of the descending horn of the ventricle and comes into relation at its termination with the amygdaloid nucleus. The tail of the nucleus and the amygdaloid nucleus are to be seen in the roof of the inferior cornu of the ventricle.

The **lenticular nucleus,** or extra-ventricular part of the corpus striatum, may be recognized in a horizontal section of the hemisphere. Such a horizontal section should now be made through the right hemisphere at such a level as will cut the upper part of the caudate nucleus and the upper part of the thalamus. In such a section it appears as a mass having the shape of a double convex lens (Fig. 248), separated from the caudate nucleus and from the optic thalamus farther back by the band of fibres referred to above as the **internal capsule.** In the same section one detects a curved white band on the outer side of the lenticular nucleus (Fig. 248), the **external capsule,** which is also a band of fibres cut in such a section transversely to their long axes. Thus the lenticular nucleus appears to be enclosed in such a horizontal section by a white capsule, from which arose the very inappropriate names, the internal and the external capsule, to designate these bands of fibres. At a later stage of the dissection (p.533) a coronal section of the hemisphere will show that the lenticular nucleus in such coronal section is wedge-shaped with the small end of the wedge projecting mesially and that the wedge appears thus to be divided into *three segments* by respectively the **internal** and the **external medullary laminæ,** which are merely the bands of fibres mentioned above as either emanating from the cells of the nucleus or as passing to these cells to form arborizations with them. The outermost segment, from its deeply pigmented character, is called the **putamen,** while the middle and inner segments from their lighter yellowish color are collectively called the **globus pallidus.** The lenticular nucleus, as mentioned above, is continuous anteriorly with the caudate nucleus and is likewise continuous with a band of gray matter lying upon its outer side, the **claustrum.** It approaches the surface of the hemisphere at the anterior perforated lamina.

The **claustrum,** appearing as a vertical, somewhat wavy sheet of gray matter situated upon the outer side of the lenticular nucleus, is seen both in horizontal section, where it appears on the outer side of the external capsule, and in coronal section (Fig. 249). It is regarded as belonging to the cortex of the temporal lobe.

Since the amygdaloid nucleus and the tail of the caudate nucleus are continuous, and since the caudate nucleus and the lenticular nucleus

FIG. 249.—Frontal section of brain passing through caudate and lenticular nuclei and thalamus, showing relation of internal capsule to internal nuclei.

are continuous with each other in front, and the latter is in turn continuous with the claustrum and the claustrum is a part of the cortex of the temporal lobe, the close relation between this collection of gray matter and the cortex of the hemisphere is evident. The corpus striatum, the amygdaloid nucleus and the claustrum are collectively called the **basal ganglia.**

THE INTERNAL CAPSULE.—Returning to our horizontal section (Fig. 248), the internal capsule appears as a band with the lenticular nucleus external to it and the caudate nucleus and optic thalamus lying to its inner side. The convexity of the lenticular nucleus deter-

mines a curvature in the internal capsule as seen in horizontal section, the sharpest point of the curve being designated the **genu** or **knee** of the capsule. As stated above, what appears in such a section as a white band is merely a section of fibres, transverse to their long axes, which are on their way either upward or downward. If followed upward the fibres diverge from each other so that instead of constituting a compact band they spread out to almost all parts of the cortex of the hemisphere as the **corona radiata.**

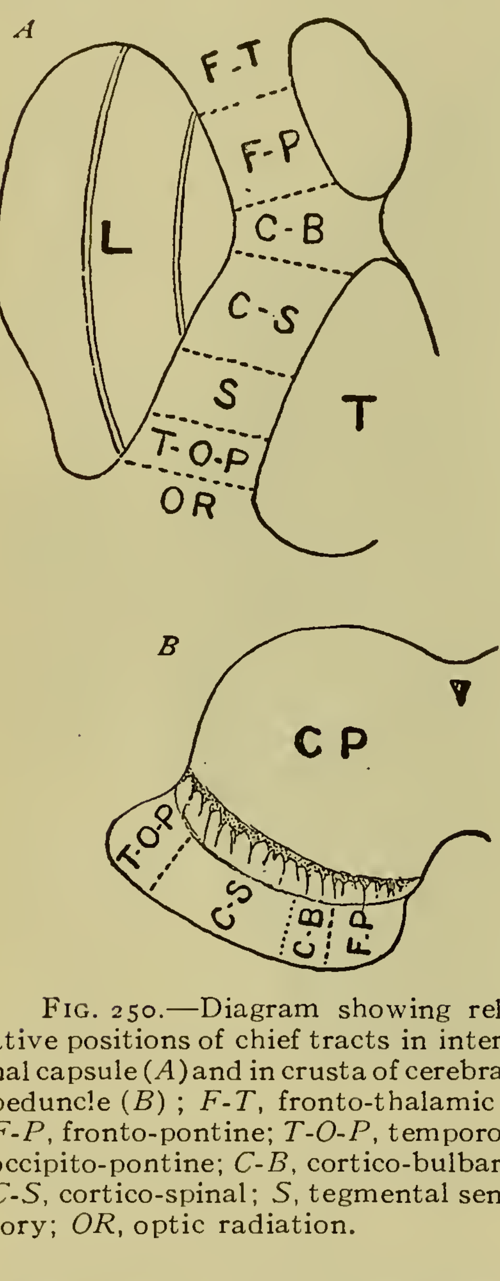

FIG. 250.—Diagram showing relative positions of chief tracts in internal capsule (*A*) and in crusta of cerebral peduncle (*B*); *F-T*, fronto-thalamic; *F-P*, fronto-pontine; *T-O-P*, temporo-occipito-pontine; *C-B*, cortico-bulbar; *C-S*, cortico-spinal; *S*, tegmental sensory; *OR*, optic radiation.

At the **knee** or **genu** of the capsule are found the *geniculate fibres*, efferent (motor) fibres for the face and tongue; they are axones of cells in the centres for the face and tongue in the lower part of the precentral convolution. Traced downward they arborize about the cells of the deep nuclei of the cranial nerves supplying the parts in question. In the **anterior third of the posterior segment** of the capsule (Fig. 250) are efferent fibres for the arm, which are the axones of cells of the arm area in the precentral convolution, while in the **middle third of the posterior segment** are motor or efferent fibres for the leg which are axones of the cells of the leg area in the motor zone of the cortex. These three groups of fibres, passing downward to the base of the hemisphere, emerge here as the pyramidal fibres of the crusta or ventral portion of the cerebral peduncle, of which they occupy the middle three fifths. The **posterior third of the posterior segment** of the capsule consists of afferent or sensory fibres, this segment being known as the **sensory cross=way.** The more posterior fibres of this group constitute the **optic radiation** (the posterior peduncle of the thalamus), which are axones of cells situated in the various deep nuclei of the optic nerve (pulvinar of the thalamus, anterior quadrigeminal body and external geniculate body). Other fibres of the sensory cross-way are continuations of sensory fibres encountered at lower levels, such as the *cortico-pontal*, found in the outer fifth of the crusta of the crus. In the **anterior segment** of the capsule are the *thalamo-frontal fibres* which emanate from the anterior part of the thalamus (anterior peduncle of the thalamus) and which go to the frontal lobe (Fig. 250), and also the *fronto-pontal fibres*

which are encountered below in the inner fifth of the crusta of the crus and which connect the pontal nuclei with the prefrontal region of the cortex.

The *lenticulo-striate artery*, referred to on page 497 as supplying the corpus striatum and optic thalamus and the internal capsule, was styled by Charcot the artery of cerebral hemorrhage. If, by rupture of this vessel, a blood-clot presses upon or destroys the posterior limb of the internal capsule, the result is **hemiplegia,** that is, paralysis of one lateral half of the body. Such rupture of a cerebral blood-vessel is known as *cerebral apoplexy*. The paralysis will be temporary or permanent according to whether the fibre-tracts are merely pressed upon or whether they are destroyed by the effusion of blood.

The right and left hemispheres may now be separated from each other by a mesial sagittal section. This will afford opportunity to examine more fully the mesial surface of the left hemisphere and also that of the optic thalamus.

The **anterior commissure,** a bundle of fibres connecting the anterior parts of the temporal lobes, crosses the mid-plane just in front of the anterior pillars of the fornix and helps them to bound the third ventricle in front (Fig. 246). In the sagittal section just made it appears as a circular area in front of the pillar of the fornix. It should be followed in the right half of the specimen in its course transversely outward beneath the putamen and then backward to the temporal lobe, the remains of the lenticular nucleus being removed to expose it. The anterior commissure is the pathway of some of the olfactory fibres.

The **anterior pillar of the fornix** should be followed down to the mammillary body. The **bundle of Vicq d'Azyr** should be traced upward from the nucleus of this body to the anterior nucleus of the thalamus, exposing it by scraping the gray matter from the mesial surface of the thalamus. Both these fibre-bundles are also olfactory pathways.

Coronal sections should now be made through the left hemisphere beginning near the frontal pole. These will afford views of the basal ganglia and internal capsule.

THE METENCEPHALON.

The metencephalon, derived from the secondary hind-brain vesicle, includes the **pons Varolii** and the **cerebellum** with **parts of the superior cerebellar peduncles.** The pons results from the marked thickening of the ventral wall of the vesicle, while the cerebellum is produced from the cushion-like evagination of the back part of the dorsal wall, the remaining part of the dorsal wall thickening only to a slight extent to give rise to the **valve of Vieussens.** The valve, triangular in outline, is united by its lateral margins with the superior cerebellar peduncles, which latter result from the side walls of the vesicle. What is left of the cavity of the vesicle becomes the anterior half of the fourth ventricle.

THE PONS VAROLII.

The pons, having a length of about one inch, is the link which connects the cerebrum with the medulla and the cerebellum. Its **ventral surface,** markedly convex, comes into relation with the basilar process of the occipital bone and the dorsum ephippii of the sphenoid, while its **dorsal surface,** concave, forms the floor of the anterior half of the fourth ventricle. The ventral or ventro-lateral surface presents a little nearer its upper margin than its lower the attachment of the large sensory and small motor roots of the fifth nerve. The ventral surface is marked by a shallow mesial furrow and presents a very distinct transverse striation significant of the fact that a part of the ventral portion of the pons consists of transverse fibres which are continued first laterally and later dorsally as the **middle peduncle** of the cerebellum of each side. The **dorsal surface** of the pons is continuous along its lateral margins with the rounded elevations which constitute parts of the superior peduncles of the cerebellum. At present the dorsal surface is hidden by the superior peduncles and the triangular lamina, the **valve of Vieussens,** which is continuous by its lateral margins with the superior peduncles and which thus closes in the anterior half of the fourth ventricle. The internal architecture of the pons will be considered after the study of the fourth ventricle (p. 546).

THE CEREBELLUM.

The cerebellum, one of the four primary subdivisions of the brain, occupies the posterior cranial fossa lying beneath the tentorium cerebelli, by which structure it is separated from the cerebrum. Its surfaces should be denuded of pia mater after tracing such of the arteries as have not been followed (p. 498). The pia between its under surface and the medulla should be left, however.

The **dorsal surface** of the cerebellum is convex, presenting a median longitudinal elevation, the **superior vermiform process** or **worm,** this being the upper surface of the vermiform process or **median lobe.** The **median lobe** is flanked laterally by the two **lateral hemispheres.** At the posterior extremity of the superior worm is an indentation, the **posterior incision,** while indenting the **anterior border** is the wider **anterior incision.**

The surface is marked by fissures in an entirely different manner from the way in which the surface of the cerebrum is marked. These fissures are approximately parallel with each other and, generally speaking, arch forward from the positions they occupy upon the vermiform process, dividing the surface into **lobes** and **folia** (Fig. 251).

The cerebellum is connected with the cerebrum by the **superior cerebellar peduncles,** noted above, which should be exposed to their fullest extent by gently drawing backward the anterior margin of the

cerebellum. While these peduncles appear distinct from each other in the region of the mid-brain, back of this region where they are in relation with the pons and where they are rather widely separated from each other, they are connected by a thin lamina, the valve of Vieussens. This should not be disturbed in the present stage of the dissection.

The cerebellum is connected with the pons by the **middle peduncles.** If the dissector will invert the brain and note the ventral portion of the pons with its easily recognizable transverse striations he will be able readily to follow these fibre bundles laterally and dorsally into the cerebellum.

The cerebellum is connected with the medulla by the **inferior peduncles** or **restiform bodies.** If the student will inspect the dorsal sur-

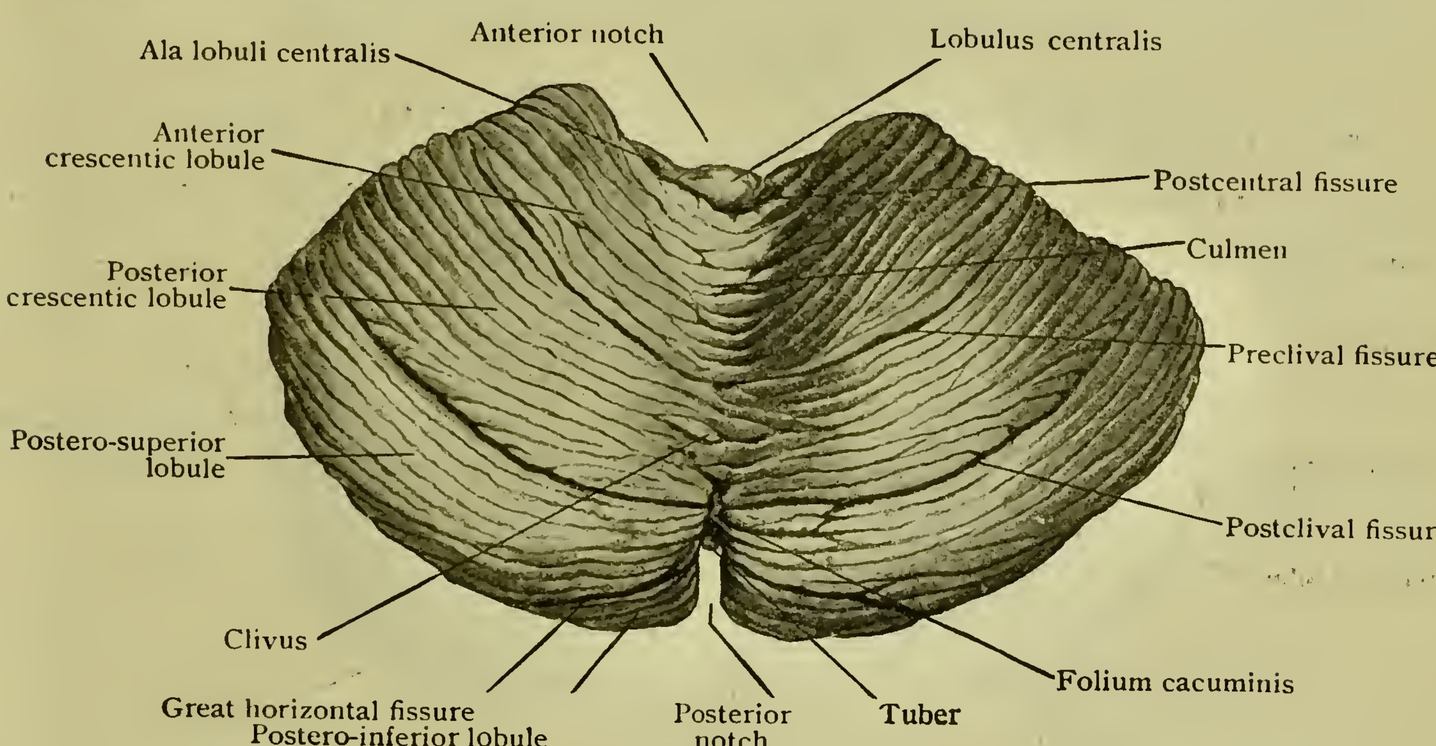

FIG. 251.—Cerebellum viewed from above.

face of the medulla he will note a rounded and obliquely directed elevation beginning just above the clava, which he may trace into the lateral portion of the cerebellum.

The Upper Surface of the Cerebellum.—The **great horizontal fissure** of the cerebellum begins near the point where the middle peduncle enters the organ and passing around the lateral and posterior margin of the upper surface and dipping into the posterior incision is continuous with a similarly arranged fissure on the left cerebellar lobe. It serves as the line of division between the superior and the inferior surfaces. The surface of the cerebellum is divided into lobes and convolutions in accordance with the arrangement of the central white matter as seen in a sagittal mesial section (Fig. 253); consequently, the markings on the upper surface of the superior worm determine the division of the upper surfaces of the hemispheres. Thus the most anterior convolution of the

superior worm is a little projection, the **lingula,** which rests upon the dorsal surface of the valve; note its position on the mesial section (Fig. 253), noting also the fact that the valve is continuous with the central white core of the cerebellum. In order to expose the lingula the next convolution, the **lobulus centralis,** must be slightly displaced backwards. The convolutions on the lateral hemispheres of the cerebellum which correspond with the lobulus centralis are the **alæ lobuli centralis.** Back of the lobulus centralis is the **culmen monticuli,** which is flanked on either side by the **anterior crescentic convolution,** and back of this is the **clivus monticuli,** sloping downward and backward, flanked on either side by the **posterior crescentic convolution;** still farther back is the **folium cacuminis,** rather embedded in the posterior incision, which is continuous on either side with the **posterior superior lobule.**

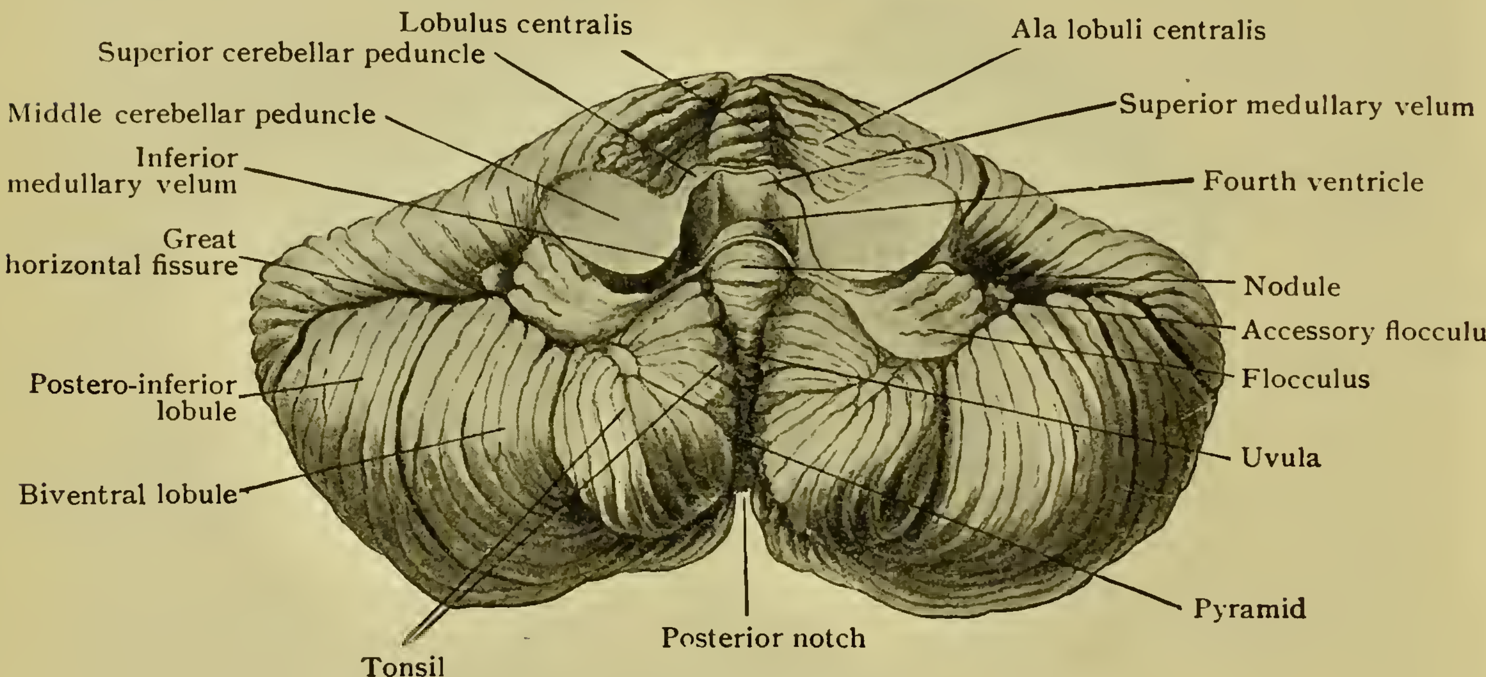

FIG. 252.—Inferior aspect of cerebellum, after removal of pons and medulla.

The Inferior Surface of the Cerebellum.—The inferior surface cannot be studied to the best advantage without detachment of the cerebellum from the pons and the medulla, which is not desirable at this stage of the work. It can be seen, however, that the inferior surface is markedly convex and that the two hemispheres are separated from each other by a deep depression called the vallecula, the roof of which depression or fissure in the erect position of the brain is formed by the inferior surface of the worm. By reference again to the sagittal section (Fig. 253) it will be seen that the markings on the inferior surface of the worm, like those on its upper surface, are determined by the central white matter of the worm or **arbor vitæ.** Although the student cannot at present examine these convolutions in the dissection itself it is well to study them at this time, using the figures and the dissection conjointly.

The most anterior convolution of the inferior worm is the **nodulus,** the surface of which rests against the dorsal surface of the inferior choroidal tela. Referring to the sagittal section (Fig. 253) it will be seen that the tela is continuous with the central white matter of the worm just as is the valve. This arrangement becomes intelligible if one takes into account the fact that the cerebellum is developed as an evagination or out-pouching from the back part of the roof of the hind-brain vesicle. A sheet of white matter, the **inferior medullary velum,** passes out on either side from the nodulus to connect with a small convolution, the **flocculus.** The small lobule behind the nodulus is the **uvula,** which is flanked on either side by the **amygdala** or **tonsil,** each amygdala being separated from the uvula by a narrow strip, the **furrowed**

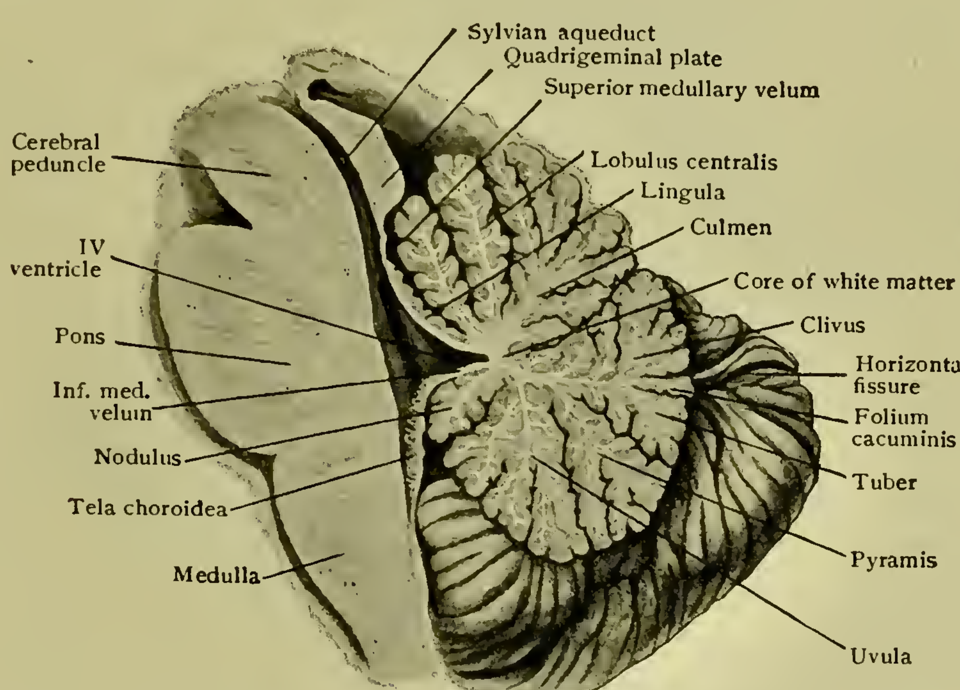

FIG. 253.—Mesial sagittal section of brain-stem and cerebellum, showing fourth ventricle, Sylvian aqueduct, and cerebellar worm.

band. The **pyramis** is the convolution situated behind the uvula continued laterally into the **biventral convolution** of each lateral hemisphere as well as into the **posterior crescentic;** while behind the pyramis is the **tuber valvulæ,** flanked on either side by the **posterior inferior semilunar lobule.**

Restoring the brain to its proper position with the base downward a mesial longitudinal incision may now be made through the vermiform process and the right lateral half of the cerebellum may be gently raised with the fingers so as to expose the roof of the fourth ventricle. The depth of this incision must not be too great in order that the roof of the fourth ventricle may not be injured. Continuing the elevation of the anterior part of the right half, the entrance of the superior cerebellar peduncle may be noted and if the upper portion of the right hemisphere is carefully torn away from the lower portion by insinuating the fingers

into the horizontal fissure, the mode of entrance of the middle and inferior peduncles may also be noted. The remaining portion of the right half of the cerebellum may now be carefully removed, the three peduncles of the right side being cut close to their attachment to the cerebellum. This gives opportunity to inspect the mesial section as shown by the left half which remains in position and this should be compared with Fig. 253.

The left half of the cerebellum should now be removed, the dissector first carefully elevating the mesial portion of it so as to leave intact the valve and as much of the inferior choroidal tela as may be present, and then incising the three peduncles of the left side close to their attachment to the cerebellum.

The **internal structure** of the cerebellum may be studied upon this left half of the organ by making successive sections in the coronal plane so as to cut directly across the long axis of the superior worm. As the sections are carried back one may note the presence of masses of gray matter in the interior of the white matter of the cerebellum. The **nucleus fastigii** (nucleus of the roof) is near the lower part of the hemisphere close to the roof of the fourth ventricle, from which circumstance it takes its name, and near the mesial plane. Farther back and farther up are seen the **nucleus emboliformis,** a club-shaped mass with the small end forward, and the **nucleus globosus,** consisting of several masses of gray matter. The largest nucleus is the **corpus dentatum** or dentate nucleus situated to the outer side of the smaller nuclei. This nucleus presents an aperture or hilum looking toward the mesial plane occupied by white matter which is the fibres of the superior peduncles as they emerge from this nucleus. A crescentic band seen on the outer side of the dentate nucleus represents the fibres of the inferior peduncle as they are cut in this section.

THE MYELENCEPHALON OR MEDULLA OBLONGATA.

The medulla, appearing as if the upper somewhat enlarged end of the spinal cord, has a length of 2.5 cm. (1 inch). Directly continuous below with the spinal cord, from which it is not differentiated by any line of demarcation, it is continuous above with the pons, although the distinction between the two is definitely indicated by a transverse groove. It lies partly within the spinal canal and partly within the cranial cavity upon the basilar process of the occipital bone. Now inverting the specimen and referring to Fig. 254, it will be seen that the **ventral surface** of the medulla presents the **ventro-mesial fissure,** continuous below with that of the spinal cord, but ending abruptly above in a small cul-de-sac, the **foramen cæcum.** The **anterior pyramids** of the medulla are seen, one on each side of this fissure, as rounded elevations larger above than

below. When the superficial, transversely directed fibres of the pons are removed, it is seen that the pyramids of the medulla are continuous with the longitudinal fibres of the pons. Oblique bands passing between the pyramids, across the fissure, indicate the decussation here of those fibres of the pyramids which constitute the crossed pyramidal tracts of the spinal cord. The **ventro-lateral fissure,** upon the outer side of the pyramid, indicates the lateral limit of the **anterior area** of the medulla, separating it from the **lateral area.** The fibres of the twelfth cranial

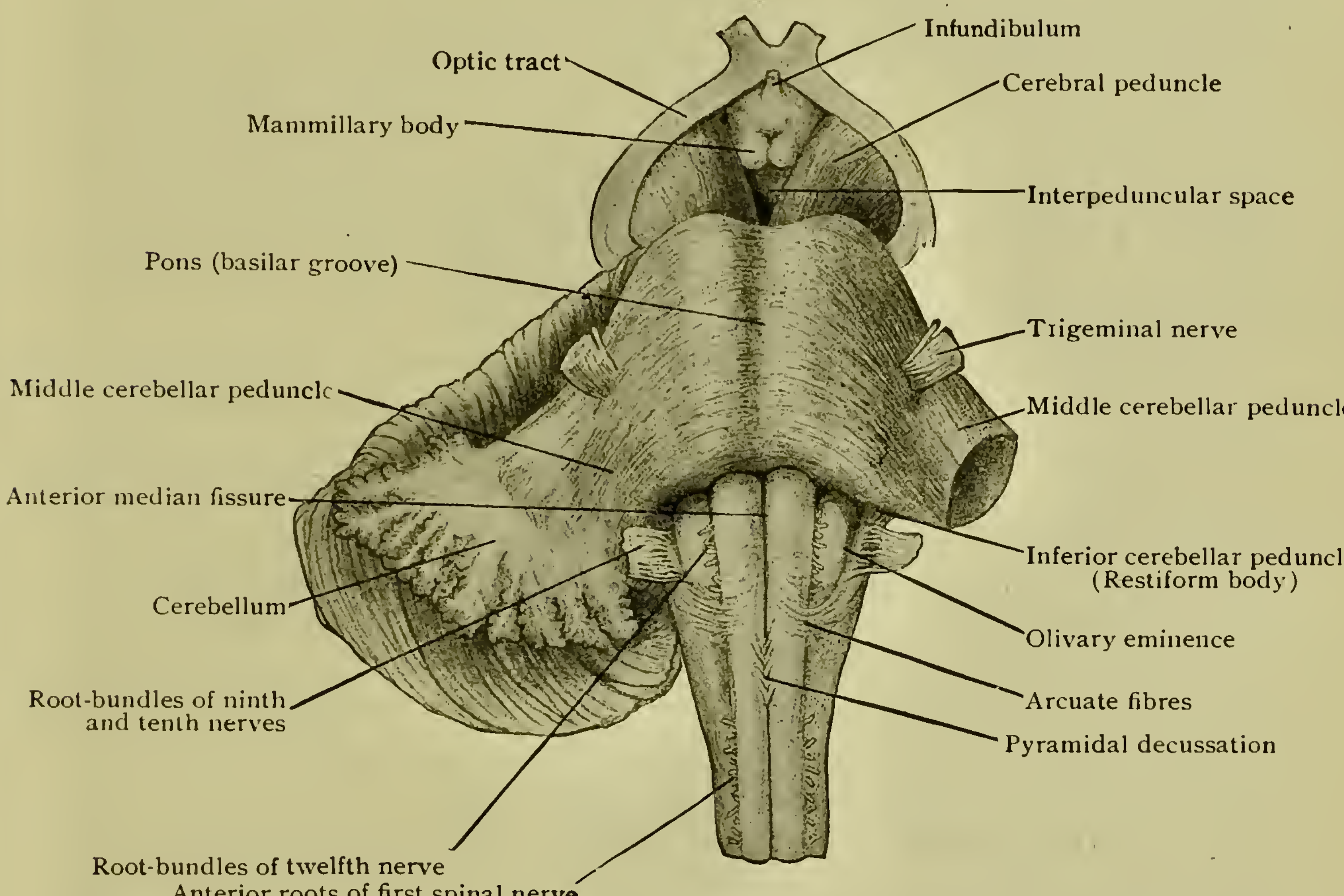

FIG. 254.—Brain-stem viewed from in front, showing ventral aspect of medulla, pons and mid-brain.

nerve (hypoglossal) emerge at the ventro-lateral furrow, being in series with the ventral root fibres of the spinal nerves. The **olivary eminence** occupies approximately the upper half of the lateral area, being separated behind from the **posterior area** by the **parolivary fossa** or **post-olivary sulcus.** The transverse striations seen upon the anterior pyramids and the olivary eminences are the **superficial anterior arcuate fibres,** which emerge from the ventro-mesial fissure and pass around to join the restiform body. In the post-olivary sulcus are found the emerging fibres of the ninth, tenth and eleventh cranial nerves, these corresponding in a general way with the line of attachment of the dorsal roots of the spinal nerves to the spinal cord.

The **posterior area** (Fig. 255) presents in its lower half, or closed part, the dorso-mesial fissure, continuous with the corresponding fissure of the cord. Upon each side of this fissure is the **funiculus gracilis,** which is directly continuous with the tract of Goll of the cord.

The funiculus gracilis if traced upward is seen to terminate in a slight enlargement, the **clava,** situated about the level of the middle of the medulla. This enlargement is due to an underlying gray nucleus, the **nucleus of Goll** or **nucleus gracilis,** the cells of which receive the arborizations of the fibres coming up from the spinal cord through the funiculus gracilis.

The **funiculus cuneatus,** lying upon the outer side of the funiculus gracilis, is the direct continuation of the tract of Burdach of the cord; it also terminates about the level of the middle of the medulla in an enlargement due to an underlying gray nucleus, the **nucleus cuneatus** or **nucleus of Burdach,** the cells of which receive the arborizations of the fibres of the tract of Burdach coming up from the spinal cord by way of the funiculus cuneatus.

The **funiculus of Rolando,** another rounded elongated eminence, situated upon the outer side of the funiculus cuneatus, does not represent any structure of the spinal cord, being peculiar to the medulla. It likewise terminates in a rounded eminence, the **tubercle of Rolando.** Apparently a continuation of these three bands is seen in the form of a much larger rounded prominence which continues to diverge from the mid-line and to enter the cerebellum; this is the **restiform body** or **inferior peduncle** of the cerebellum which constitutes an important link between that part of the brain and the medulla. Though apparently a continuation of the funiculus gracilis, funiculus cuneatus and funiculus of Rolando, it has practically no connection with these structures except for the **superficial posterior arcuate fibres** emanating from the cells of the nucleus of Goll and the nucleus of Burdach, which join it and contribute to its formation. If the cerebellum and the medulla have been separated without lacerating the intervening pia mater, the **tela choroidea inferior** will be seen filling in the space between the diverging clavæ and restiform bodies, this being in fact a part of the dorsal surface of the medulla. It is one of those areas, of which there are several others, where the wall of the original neural canal remains extremely thin, the wall in this instance consisting of little more than a layer of ependyma fused with an overlying layer of pia mater except for a few localized thickenings. These thickened areas are first the **obex,** a triangular plate occupying the lower angle of the tela, and two narrow bands, one in either lateral edge of the tela, the **ligulæ.** In addition to these the **inferior** or **posterior medullary velum** appears as a narrow band with concave lower margins at the upper part of the tela where it is continuous with the cerebellum. The **foramen of Majendie** in the mid-

line of the tela is an aperture opening into the fourth ventricle by which that cavity communicates with the overlying cisterna magna. The **foramina of Luschka** are small apertures in the lateral parts of the tela.

The dissector will now have demonstrated the continuity of the medulla with the spinal cord, its connection with the cerebellum by the inferior cerebellar peduncles or restiform bodies, and its continuity anteriorly with the pons.

THE FOURTH VENTRICLE.—The cerebellum having been removed, the **roof** of the fourth ventricle is exposed. This cavity represents the cavity of the metencephalon (secondary hind-brain) and of the mye-

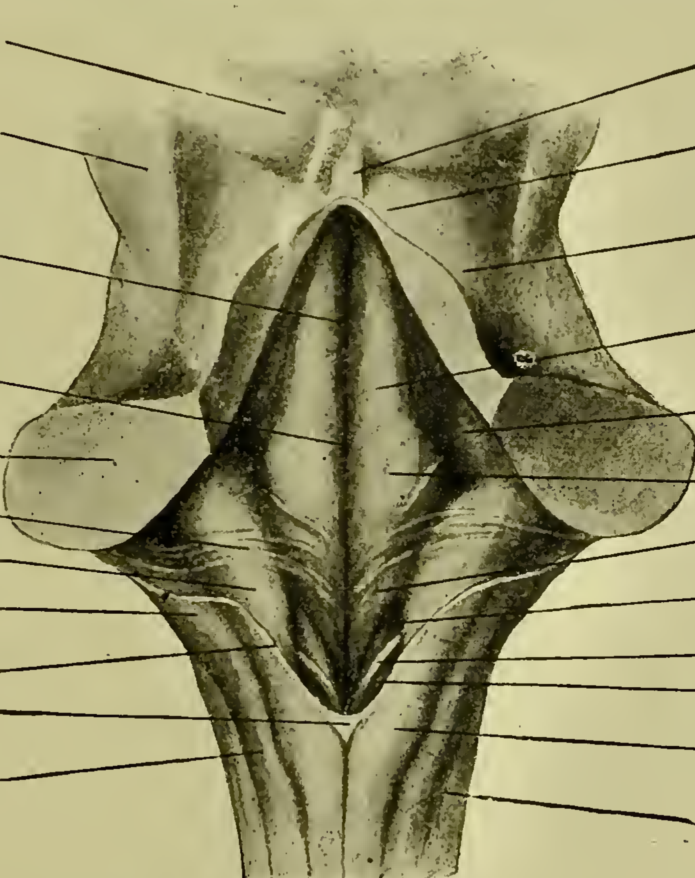

FIG. 255.—Medulla and floor of fourth ventricle seen from behind, after removal of cerebellum and ventricular roof. × 1½.

lencephalon (after-brain) and hence its ventral wall or floor is constituted by the pons and the medulla. Reference to the sagittal section of the brain (Fig. 253) will show the relation to it of the valve, the nodulus of the cerebellum, and the tela choroidea inferior, these structures roofing it in from before backward in the order named. The tela choroidea inferior should now be examined if the dissector's efforts to preserve it have been successful. Comparing the account of it given above he should identify the foramen of Majendie, the obex and the ligulæ. The tela should then be detached along its lateral margins and reflected downward. This should reveal the **inferior medullary velum** at its upper border, with its concave lower edge, and the **choroid plexuses** of the fourth ventricle which are in relation with the lower portion of

the velum. The **valve** should also be noted carefully in its relations to the ventricular cavity, and to the superior cerebellar peduncles, and the points of exit (superficial origin) of the fourth cranial (trochlear) nerves upon its dorsal surface should be noted. The valve may now be detached from the peduncles of the cerebellum and removed.

The **lateral** boundaries of the fourth ventricle, now fully exposed, are the superior cerebellar peduncles for the anterior half and the inferior cerebellar peduncles or restiform bodies for the posterior half, except that near the lower angle the clavæ and the funiculi graciles assist. The restiform bodies are crossed just below the outer angles by striations which, if examined closely, are seen to be fibres traceable to the auditory nerve, these fibres being in fact the dorsal root of the cochlear division of that nerve. Traced inward the fibres spread out over the lateral angle of the floor of the ventricle and are finally lost in the mesial fissure of the floor. At the lower angle of the floor is a marking, the **calamus scriptorius.** A probe may be passed from this lower angle into the central canal of the spinal cord. The *mesial furrow* traverses the floor of the ventricle throughout. The **trigonum vagi** (ala cinerea) is a triangular elevation in the lower angle of the ventricle bordering the mesial furrow. It is due to the backward projection of a portion of the nucleus common to the vagus, the glosso-pharyngeal and the cerebral part of the spinal accessory nerves. The **trigonum hypoglossi,** also a triangular marking adjacent to the mesial furrow, is situated just above the trigonum vagi. It is due to the projection of the chief nucleus of the hypoglossal nerve. The lateral angle of the ventricle is marked by an elevation, the **tuberculum acusticum,** crossed transversely by the fibres of the dorsal root of the cochlear nerve mentioned above. The **eminentia teres** is an elongated, convex elevation next the mesial furrow seen in the anterior half of the floor. It is produced by the intra-pontine course of the seventh nerve as it arches over the nucleus of the sixth nerve. The **fovea superior** is seen laterally to the terete eminence and presents a transverse striation, the **conductor sonorus.** The **locus cœruleus** is a pale bluish marking upon the floor external to and above the fovea superior and reveals the presence in the pons of a collection of nerve-cells, the substantia ferruginea. At the upper angle of the ventricle is seen the posterior orifice of the aqueduct of Sylvius.

The **internal structure of the medulla,** although, in a sense, foreign to a work of this kind, must nevertheless be studied in this connection, as must also that of the pons and the mid-brain, if one is to gain an intelligent idea of the brain as a whole. As a preliminary consideration, it may be pointed out that the medulla results from the after-brain vesicle, the epithelial walls of which thicken to an unequal degree in different parts, what is left of the cavity of the vesicle persisting as the

lower half of the fourth ventricle. While the great mass of the medulla results from the thickening of the ventral and the lateral walls of the vesicle, the dorsal wall of the latter remains extremely thin, as pointed out above, to form the tela choroidea inferior. A consideration of great importance in understanding the structure of the medulla is the fact that the complicated arrangement of its parts, as compared with the corresponding parts of the spinal cord, is brought about by several factors: first, the rearrangement in the medulla of many of the fibre-tracts encountered in the spinal cord; second, by the consequent rearrangement of the gray matter of the medulla as compared with corresponding masses of gray matter in the spinal cord; third, by the addition of new masses of gray matter not found in the spinal cord;

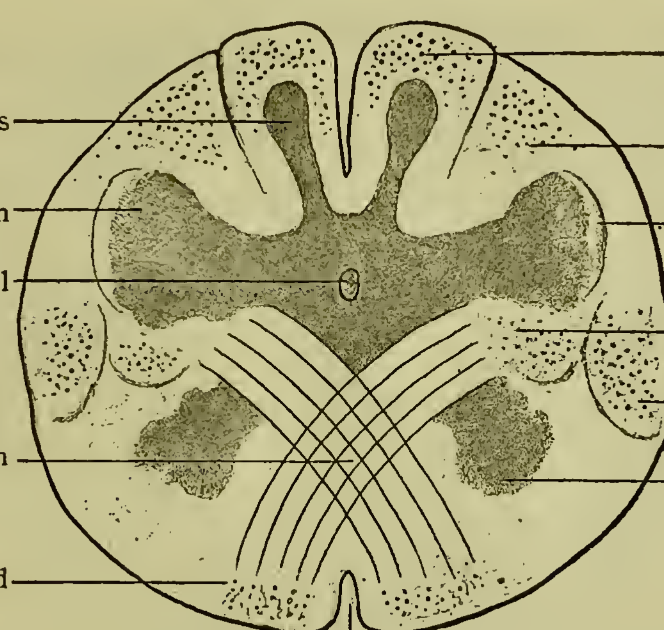

FIG. 256.—Transverse section through lower, closed, part of medulla, showing motor decussation; diagrammatic.

and, fourth, by the presence of additional axones emanating from or passing to these new masses of gray matter.

Although the proper study of sections of the medulla necessitates proper preliminary staining and microscopic examination, the student may gain some little information from an examination of a dissecting-room section by means of a hand-glass. In a transverse section of the medulla below the clavæ (Fig. 256) the most conspicuous feature is the **decussation of the pyramids.** As mentioned above, from 80 to 90 per cent. of the fibres of the anterior pyramids decussate to become the crossed pyramidal tracts of the spinal cord. The decussation of these fibres produces an important secondary modification in the structure of the medulla, in that the fibres, in cutting across to the opposite side, isolate the heads of the anterior gray horns; these isolated heads are known now as the **lateral nuclei.** Other changes to be noted as compared with the spinal cord are that the central canal is nearer the dorsal

surface than it is in the cord and that the heads of the posterior gray horns are bent laterally and enlarged. The funiculi graciles and cuneati occupy the same relative positions as the tracts of Goll and Burdach of the cord with which they are continuous. A section at a higher level, but still below the olivary eminences, will show the **nucleus gracilis** as a mass of gray matter apparently grown out from the base of the posterior horn, and the **nucleus cuneatus** as a similar mass of gray matter added to the dorsal aspect of the head of the posterior gray horn. The fibres of the funiculus gracilis and the funiculus cuneatus and, consequently, of the tracts of Goll and Burdach, terminate by arborizing about the cells of these nuclei. A still more striking feature of a section at this level is the **sensory decussation,** by which is meant that

FIG. 257.—Transverse section through lower, closed, part of medulla at a higher level than Fig. 256, showing sensory decussation; diagrammatic.

the axones of the cells of the nuclei gracilis and cuneatus pass forward and inward, isolating the head of the posterior horn from its base, and cross the mesial plane to take up a position on the opposite side immediately dorsal to the anterior pyramids (Fig. 257). A majority of the fibres that thus cross as the sensory decussation constitute the **deep arcuate fibres** and after they have crossed they form a bundle of afferent fibres known as the **fillet** or **lemniscus,** although strictly speaking these names are applicable only after these fibres are joined by some fibres originating in the olivary body of the medulla. Other fibres that pass forward and inward with the deep arcuate fibres emerge at the ventromesial fissure as the **superficial anterior arcuate fibres** (p. 539). The **posterior superficial arcuate fibres** pass from the cells of the nucleus gracilis and nucleus cuneatus to the restiform body of the same side and with it to the cerebellum (Fig. 257).

Another striking feature of a section at this level is the enlargement of the **substantia gelatinosa** capping the posterior gray horn with which it is in relation externally, the crescentic marking indicating a bundle of descending fibres belonging to the dorsal root of the fifth nerve, these fibres being on their way downward from the middle of the pons to terminate at successive levels by arborizing about cells in the posterior gray horn as far down as the level of the second cervical nerve.

A section through the middle of the olivary eminences (Fig. 258) shows these eminences to be produced by a nucleus known as the **olivary body,** which is composed of a somewhat irregular sac-like layer of gray matter with an aperture or **hilum** looking toward the mesial plane. Through the hilum fibres pass in and out either as axones of cells

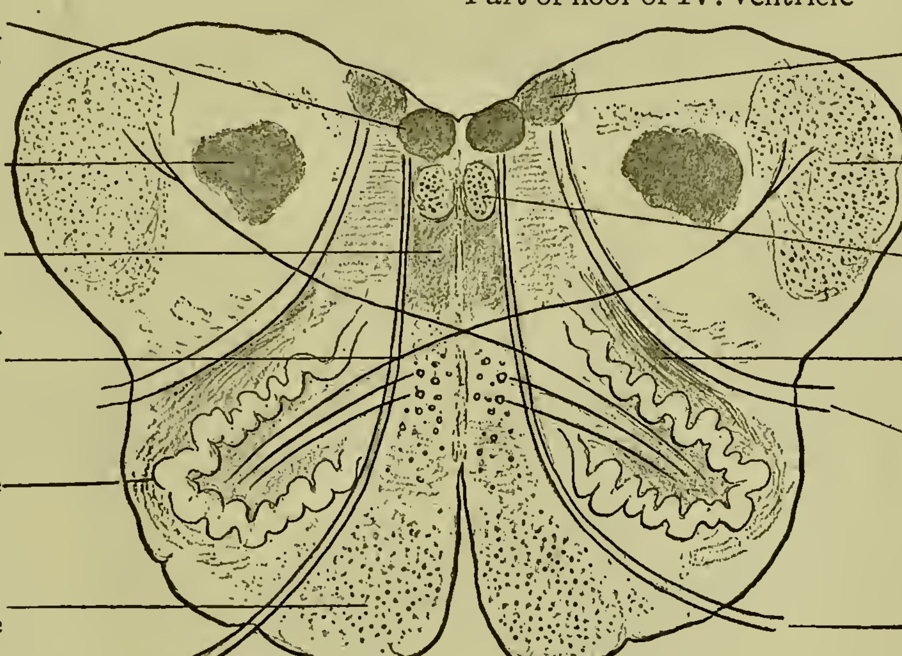

FIG. 258.—Transverse section through open part of medulla, cutting inferior olivary nucleus; diagrammatic.

contained within the nucleus or to form arborizations about such cells. Among these fibres are some which join the deep arcuate fibres to assist in forming the fillet; the *cerebello-olivary fibres* which pass to the cerebellar cortex of the opposite side in company with the restiform body; and some *olivo-spinal fibres* which pass down to take up a position in the antero-lateral tract of the spinal cord. The **mesial** and **dorsal accessory olivary nuclei** are found respectively upon the mesial and dorsal aspects of the olive. The **direct cerebellar tract of the spinal cord** is continued into the medulla as the inferior peduncle of the cerebellum or restiform body, as may be seen upon superficial inspection of the medulla, but, as indicated above, the restiform body includes considerably more than the direct cerebellar tract of the cord. Thus the **restiform body** is made up, in addition to the direct cerebellar tract, of the *superficial posterior arcuate fibres*, thus indirectly continuing a part of

the tracts of Goll and Burdach of the cord; of *cerebello-olivary* and *olivo-cerebellar fibres* connecting the cerebellar cortex with the olive of the medulla; and of *cerebello-nuclear fibres* connecting the cerebellum with various cranial nerve nuclei of the medulla, notably the vestibular nuclei of the auditory nerve. Another striking feature of a section at this level is the expansion of the central canal into the cavity of the fourth ventricle. This expansion is due, as pointed out above, to the fact that the dorsal wall of the hind-brain vesicle remains very thin throughout that region corresponding to the upper half of the medulla. The disposition of the gray matter brought about by these various changes, such as the decussation of the motor and sensory fibres and the expansion of the central canal, is of great interest. Thus, the amputated *head of the anterior gray horn*, recognized in the lower part of the medulla as the lateral nucleus, has become broken up and, with the lateral horn-cells, is represented by the **dorso-lateral nucleus** and the **nucleus ambiguus,** which constitute the motor nucleus for the ninth, tenth and eleventh nerves. The *base of the anterior gray horn*, abutting upon the ventral surface of the central canal as before, now is brought into relation with the floor of the fourth ventricle, constituting the **nucleus of the twelfth** or **hypoglossal nerve,** the impression which it makes upon the floor of the ventricle being the trigonum hypoglossi. The *base of the posterior gray horn* constitutes the sensory part of the **accessorio-vago-glosso-pharyngeal nucleus,** which appears in part upon the floor of the fourth ventricle as the trigonum vagi.

The Internal Structure of the Pons Varolii.—The pons presents on transverse section a dorsal and a ventral portion (Fig. 259). In the uncut specimen one may note (p. 534) that the transverse striation on the ventro-lateral surface is due to transverse fibres which enter the cerebellum as its middle peduncles. The **ventral portion** of such a section shows the **superficial transverse fibres** and also the **deep transverse fibres** which likewise belong to the middle peduncle. Between these superficial and deep transverse fibres are **longitudinal fibres** which have been seen to be continuous with the anterior pyramids of the medulla below and with the ventral part of the crus above. Again referring to the transverse section, collections of gray matter—nerve-cells—are to be seen mingled with the longitudinal fibres. These are the **pontal nuclei,** which are connected on the one hand with the cerebellar cortex by the middle peduncle fibres and on the other hand with the cortex of the cerebrum by the cortico-pontine fibres (p. 532).

The **dorsal part** of the pons is made up of fibre-bundles and of collections of gray matter. Most conspicuous among the former are the **superior cerebellar peduncles** in the dorso-lateral area (p. 528). The **mesial fillet,** at the ventral boundary of the dorsal area, is the continuation of the fillet or lemniscus of the medulla (p. 544). The **lateral fillet,**

near the lateral surface and more dorsally placed than the mesial fillet, consists of fibres from the nuclei of the eighth nerve, including the nucleus of the superior olive, and from the nucleus of the lateral fillet on their way to the posterior quadrigeminal bodies. The **posterior longitudinal bundle** is near the mesial plane beneath the floor of the fourth ventricle, consisting of fibres from the antero-lateral tract of the spinal cord and from the cerebellum (p. 549).

The **tegmental gray matter** of the pons includes the **superior olive,** situated dorso-laterally to the mesial fillet; the **substantia ferruginea,** beneath the floor of the fourth ventricle and lateral to the posterior longitudinal fasciculus; the upper **sensory** and the **lower motor nuclei of the fifth nerve,** situated at the level of the emergence of its root (the

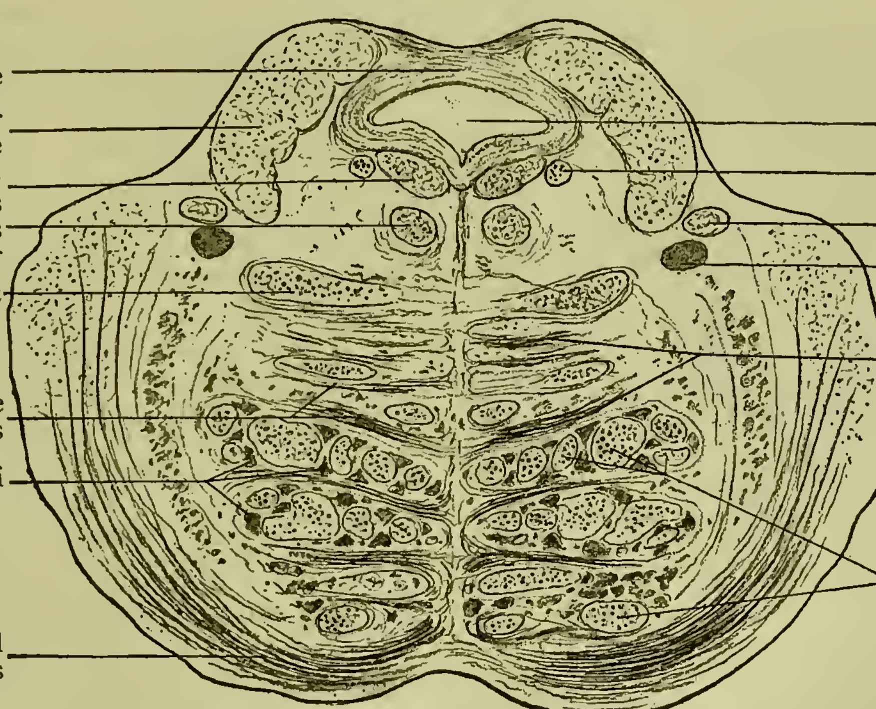

FIG. 259.—Transverse section of pons, diagrammatic.

upper motor nucleus of this nerve being in the mid-brain and the lower sensory nucleus in the spinal cord); the **nucleus of the sixth nerve** and **that of the seventh** below the level of the trigeminal exit; a **part (Deiter's nucleus) of the nucleus of the eighth nerve** in the lowest part of the tegmentum.

THE INTERNAL STRUCTURE OF THE MID-BRAIN.—A cross section of the mid-brain (Fig. 260) shows it to consist of two symmetrical lateral halves, the dorsal parts of which are continuous with each other, while the ventral portions are separated from each other by the interpeduncular space. The dorsal part or **tegmentum** of the crus is differentiated from the ventral part or **crusta** by a dark area, the **locus niger** or **substantia nigra,** composed of deeply pigmented nerve-cells and a few fibres.

The **crusta** or ventral portion of the crus is composed chiefly of fibres, which are divisible into several groups. The fibres of the *middle*

three fifths of the crusta include an inner set, the **cortico-bulbar,** which traverse the knee of the internal capsule on their way from the cortical motor area (p. 532) and which terminate in the pontal and bulbar nuclei of the cranial nerves concerned in supplying the face, tongue and vocal apparatus; and an outer set, the **cortico-spinal** (leg and arm fibres, found in the anterior two thirds of the posterior segment of the internal capsule) which are continued into the medulla as the anterior pyramids of that structure. The third group, the **cortico-pontine fibres,** include those of the *outer fifth* of the crusta, the *temporo-occipito-pontine fibres*, and those of the *inner fifth*, the *fronto-pontine*, which proceed respectively from the temporal and occipital lobes through the

FIG. 260.—Diagram of transverse section of mid-brain, the substantia nigra separating the ventral part or crusta from the dorsal part or tegmentum. The nucleus ruber and the III. nerve nucleus, which appear at a higher level, are represented by dotted lines.

sensory cross-way of the internal capsule and from the frontal lobe through the anterior limb of the capsule (p. 532); both sets of fibres pass to the pontine nuclei (p 546).

The **tegmentum** or dorsal portion of the crus includes in its structure both bundles of *fibres* and *gray nuclei.* Conspicuous parts of the gray matter are the **deep nucleus of the third** or **oculo-motor nerve** (Fig. 260) and the **nucleus ruber** or red nucleus. The **nucleus ruber** is an elongated mass of nerve-cells presenting a somewhat reddish appearance which is not limited to the region of the mid-brain but which extends forward into the sub-thalamic tegmental region. It is brought into connection with the cerebellum by the fibres of the superior peduncle, which, emerging from that organ as the axones of cells of its dentate nucleus, terminate by arborizing with the cells of the nucleus ruber; the nucleus is brought into connection with the spinal cord by

axones of its own cells which pass down through the pons and medulla into the lateral tract of the spinal cord as the *rubro-spinal tract.*

The **gray matter of the aqueduct,** a part of the gray substance of the tegmentum, is that gray matter which is in close relation with the aqueduct of Sylvius (Fig. 260). In addition to these collections, the gray matter of the tegmentum includes loosely arranged cells which are more or less scattered. Additional masses of gray matter are found in the lower part of the dorsal portion of the mid-brain in the form of the **nucleus of the fourth nerve** and the **mesencephalic motor nucleus of the fifth nerve.**

The **fibre tracts** of the tegmentum include the *superior cerebellar peduncles*, the *mesial* and *lateral fillets* and the *posterior longitudinal bundle.*

The **superior cerebellar peduncles** occupy a rather large area in a cross-section of the mid-brain (Fig. 260), gradually approaching the mesial plane as they pass forward. As stated in a preceding paragraph, the peduncles comprise fibres which are axones for the most part of cells of the cerebellar dentate nucleus and which terminate in part by arborizing about the cells of the red nucleus (*cerebello-rubral fibres*), and in part by arborizing about cells in the ventral portion of the thalamus (*cerebello-thalamic fibres*), these having reached the thalamus by traversing the sub-thalamic tegmental region.

The **fillet of the mid=brain** includes the two tracts of the pons known respectively as the mesial fillet and the lateral fillet. The mesial fillet, formed in the medulla by the deep arcuate fibres, axones of cells of the nuclei of Goll and Burdach, and by fibres from the olivary body of the medulla, passes through the dorsal portion of the pons and enters the tegmentum of the mid-brain. Some of these fibres terminate in the diffuse gray matter of the mid-brain, others terminate in the anterior quadrigeminal body, others pass on to the sub-thalamic tegmental region and the ventral part of the thalamus.

The **lateral fillet,** the fibres of which are assembled in the pons, being axones of some of the deep nuclei of the auditory nerve, terminate by arborizing with the cells of the posterior quadrigeminal bodies. The student is reminded of what was said of the posterior quadrigeminal bodies as being a part of the auditory apparatus.

The **posterior longitudinal fasciculus,** a small bundle of fibres lying near the mesial plane and beneath the aqueduct of Sylvius, is encountered also in the dorsal part of the pons and consists of fibres which come from the cerebellum by way of the middle peduncles and of some fibres from the antero-lateral tracts of the spinal cord. Traced upward some of the fibres decussate at the posterior commissure of the third ventricle. Others probably pass to the cerebral cortex by way of the posterior limb of the internal capsule. The importance of this bundle lies in

the fact that it is the connecting link between the nuclei of the third, fourth and sixth cranial nerves and possibly, also, of the optic and of the fifth.

Particular attention should be paid to the coronal sections through the front part of the hippocampal convolution and the inferior horn of the lateral ventricle. These sections will show the relation of the invaginating fold of pia mater to the fimbria and to the hippocampus major and also of the gyrus dentatus to the fimbria (Fig. 243), as indicated previously (p. 520). It should not be forgotten that this is one of the parts of the wall of the neural tube that remains extremely thin and that the choroid plexus invaginates this thin epithelial wall, the ependyma, which shuts it out from the real cavity of the ventricle.

The Fibres of the Cerebral Hemisphere.—The central white matter of the hemisphere is made up of fibres that are necessarily either processes of the cortical cells or that terminate in relation with those cells, having come from other sources; in addition to the fibres that connect the cerebral cortex with other parts of the nervous system, it is obvious that there must be fibres to connect different areas of the cortex with each other. Accordingly the fibres are classified as the **projection fibres,** or those that connect the cerebral cortex with other parts of the nervous system; **commissural fibres,** which connect the cortices of the two hemispheres; and **association fibres,** which connect parts of the same cortex.

The **projection fibres** have been encountered and studied as the fibres of the *corona radiata* and the *internal capsule* (p. 532).

The **commissural fibres** have also been seen as the fibres of the *corpus callosum* (p. 510), of the *commissura hippocampi* or *psalterium* (p. 520) and of the *anterior commissure* (p. 533). The **anterior commissure,** besides connecting the temporal lobes of the two sides, contains fibres that, (a) connect the olfactory lobes of the two sides, (b) connect the olfactory lobe of one side with the hippocampal cortex, (c) connect the olfactory lobe with the amygdaloid nucleus by way of the tænia semicircularis (p. 513).

The **association fibres** include the *short fasciculi*, which connect adjoining or neighboring convolutions, and the *long*, which connect more widely separated convolutions.

The **long association fibres** include the *cingulum* (p. 510), contained within and practically co-extensive with the limbic lobe; the *uncinate fasciculus*, connecting the orbital part of the frontal lobe with the front part of the temporal across the stem of the Sylvian fissure; the *superior* and the *inferior longitudinal fasciculi*, respectively above and below the corpus callosum, connecting convolutions in the anterior and posterior parts of the hemisphere.

The Cerebral Cortex.—The **motor area** of the cortex, according to recent experiments (Gruenbaum, Mills, Sherrington), is in the precentral convolution, the posterior parts of the second and third frontal gyri and the paracentral lobule. The motor area and the postcentral convolution are designated the *somæsthetic area.* In the **motor area,** the *centres* for the *lower limb* and *trunk* are in the upper part of the precentral gyrus and partly on the paracentral and marginal gyri; the *arm centre*, on the precentral gyrus below the leg centre, while the *centres* for the *face* and *tongue* are still lower, in the frontal operculum. The *centre for speech* is in Broca's convolution, the back part of the left third frontal, for right-handed people. *Centres for movements of the eyes* are on the posterior parts of the second and third frontal gyri.

Among the important **sensory areas** are the *visual* in the cuneus, the *auditory*, in the first temporal gyrus and the *olfactory*, chiefly in the uncus, while the *gustatory centre* has not been definitely localized. The part of the frontal lobe in front of the motor area is a *centre of intellection.*

Irritation of a motor centre for one member or for one group of muscles, as by a tumor, blood-clot or spicule of bone, may cause *focal* or *Jacksonian epilepsy;* abolition of its function causes *monoplegia.*

Owing to the relation of the motor centres to the fissures of Sylvius and Rolando, some means of determining the positions of these fissures with relation to the surface of the skull is necessary to the surgeon.

The **fissure of Sylvius** is located by a line drawn from a point one and one fourth inches horizontally back of the external angular process of the frontal bone to a point three fourths of an inch below the parietal eminence.

The **fissure of Rolando** is to be located by recalling that it begins at the upper border of the hemisphere approximately a half-inch behind the middle of the distance from the glabella to the inion and passes downward and forward, forming an angle of 71.4 degrees with the mid-line of the calvaria. The upper end of the fissure is located by measuring the distance from the glabella to the inion; the angle may be determined by the use of *Horsley's* or of *Wilson's cyrtometer*, but more simply by *Chiene's method.* The latter consists in folding diagonally a square sheet of paper, thus bisecting a right angle and so indicating an angle of 45 degrees. By folding similarly one of the halves, the angle of 45 degrees is bisected. By partly unfolding the paper so that the angle of 22.5 degrees is added to the angle of 45 degrees, an angle 67.5 degrees is obtained, which is sufficiently near 71.4 for all practical purposes.

The methods of Reid and of Anderson and Mackins are also employed, but are rather more complicated and probably no more accurate.

THE DISSECTION OF THE EYEBALL.

Since the human eyeball as found in the dissecting-room usually shows more or less deterioration, more satisfactory results are to be obtained by procuring a half-dozen fresh eyes of bullocks or sheep for purposes of study and dissection. The formalin-injected eye of the cadaver will also prove useful, however, as will appear below. Two of the specimens, after having been denuded of all fat, membranes and muscles, may be hardened by immersion in 10 or 15 per cent. formalin

or, preferably, by partial freezing by packing in cracked ice and salt. Another specimen should be injected with 15 per cent. formalin in the posterior part of the globe and laid away for twenty-four hours. One of the frozen specimens may be cut through the median sagittal plane, dividing the globe into two lateral halves, and the other in a coronal plane, through the equator. These sections should be placed in water and kept for reference, after having noted, in a general survey of the lateral halves, that the walls of the globe are constituted by *three tunics* (*vide infra*), that the *vitreous* occupies the space behind the *crystalline lens*, while the space in front of the lens is divided into the *anterior* and the *posterior* chamber by the *iris*.

Now place one of the fresh specimens, with the anterior pole or centre of the cornea upward, on several folds of damp gauze spread upon a board of soft wood. Fix it in this position with four push-pins stuck through the drawn-out muscles. Demonstrate the *areolar tissue* beneath the scleral part of the conjunctiva by injecting water under the latter, puncturing it at several points outside the margin of the cornea, and then remove the conjunctiva. Try in the same manner to demonstrate the *capsule of Tenon*, the point of the needle being stopped just short of the sclera. Complete the removal of the membranes, muscles and fat, making an effort to recognize the *vorticose veins* which emerge from the sclera between the equator and the optic nerve, and as many of the *ciliary nerves* and *arteries* as possible.

The Outer Fibrous Tunic of the Eye.—The outer tunic of the eyeball is now exposed (compare p. 430). Note the density and toughness of this coat and that it includes an anterior sixth, the transparent **cornea,** and a posterior five sixths, the opaque white **sclerotic coat** or **sclera,** the latter overlapping the former at the sclero-corneal junction. Note also the greater convexity of the cornea as compared with the sclera. Having noted the attachment of the optic nerve to the nasal side of the posterior pole, the nerve should be cut close to the sclera, when the *lamina cribrosa* of the latter, through whose openings the optic nerve fibres pass, will be seen.

To expose the deep surface of the sclera, an equatorial section of one of the fresh eyes should be made, the eyeball being held between the fingers and thumb of the left hand while a small knife-cut is made with caution to avoid cutting more than the sclera. Through this incision a small probe may be passed in various directions but not farther than one third of an inch, with the object of partially detaching the subjacent choroid from the sclera. The section should be completed with scissors, one blade being passed between the sclera and choroid, unless a probe-tipped knife is available, in which case the latter may be passed through the incision and be made to cut from within outward. When the entire equator has been encircled, the anterior half of the fibrous tunic is to be

removed by cautiously everting its cut edge, the eyeball being still held in the left hand and preferably under water, the eversion of the edge being continued until the front half of the tunic is turned inside out. Some little difficulty will be experienced in detaching the second tunic from the region of the sclero-corneal junction (scleral attachment of meridional fibres of ciliary muscle), but gentle pressure upon the adhering part of the choroid with the tip of the left thumb while the sclera is held with forceps will usually suffice. The posterior half of the sclera may now be peeled off in a similar manner, *i.e.*, turning it inside out under water. If these manœuvres have been successful, the entire second tunic of the eyeball is now exposed; if unsuccessful, the attempt should be repeated on another eye. In either case, the formalin-in-

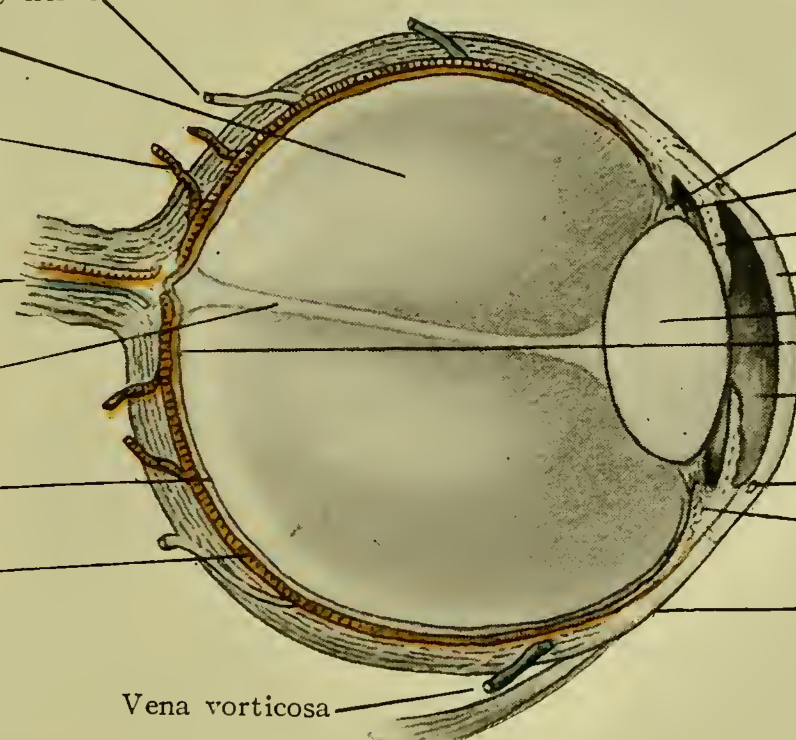

FIG. 261.—Diagram of horizontal section of right eyeball based upon bullock's eye.

jected eye of the cadaver should be cut in the same manner and will prove very instructive. In separating the choroid from the posterior half of the sclera the *short posterior ciliary arteries* should be noted as they pass from the sclera to the choroid.

The **inner surface of the sclera,** which is connected with the outer surface of the choroid by the loose-meshed *lamina suprachoroidea*, enclosing a series of spaces, the *subcleral* or *suprachoroidal lymph-space*, should now be washed and examined. The brownish pigment on this surface is the *lamina fusca*. Note the fine grooves running forward from near the optic nerve's entrance for the *ciliary nerves* and *arteries* that pass forward to the ciliary body and the iris, as well as the *vorticose veins*, perforating the sclera near the equator. Note the thickness of the sclero-

corneal junction near which, in the sclera, is the small **canal of Schlemm.**

The long ciliary nerves will be found difficult to separate from the grooves in the posterior part of the sclerotic.

The **cornea**, being transparent, is without blood-vessels except near its periphery. As a result of tertiary syphilis, a form of chronic inflammation of the cornea, *keratitis*, occurs, which is attended with a dull red or pink discoloration, the "*salmon patch*," due to the development of new blood-vessels. *Ulceration* of the cornea, sometimes resulting in *perforation* with escape of aqueous humor, is particularly prone to occur in conditions of depraved vitality.

The Uveal Tract.—The **middle** or **vascular tunic** of the eyeball, the **uveal tract** (tunica vasculosa oculi), includes the *choroid*, the *ciliary body* and the *iris*. This tract (Fig. 262), seen in its entirety in the specimen, is closely related with the outer tunic except in the anterior part of the globe where the iris diverges from the cornea, leaving a space, the **anterior chamber.** Reference to the sagittal section will show a shallow space between the iris and the lens, which is the **posterior chamber.** The deep pigmentation of the uveal tract is directly related with its function as the camera obscura of the eye, no light being permitted to enter except through the **pupil,** the aperture in the anterior part of the tract.

The Choroid.—The choroid terminates near the region of the sclero-corneal junction where the ciliary body begins. The most superficial layer of the choroid is the **lamina suprachoroidea** which has been referred to. The pigmented cellular elements of this layer give the dark color to the surface of the choroid. With the specimen showing the denuded choroid held submerged in water, the pigment should be brushed off with a camel's hair brush. This will expose the second layer, the **choroid proper** or **stroma,** the layer of large blood-vessels, and upon its surface the **venæ vorticosæ** and their whorl-like tributaries (Fig. 262) which drain the blood from the choroid, the sclera and in part from the ciliary body and iris. The venæ vorticosæ are four equi-distant trunks disposed about the equator; they and their tributaries appear in the uninjected specimen as fine white lines. The succeeding layers, the **choriocapillaris** and the **membrana vitrea,** present nothing noteworthy from the dissector's standpoint except the metallic reflex seen upon the inner surface in the bullock's eye under examination, but not in the human eye; the metallic lustre is due to an additional layer, the *tapetum fibrosum*, in the choriocapillaris. The deep surface of the choroid may be examined in one of the sagittally cut specimens or in the posterior half of the equatorially cut eye by removing the vitreous and retina.

Coloboma of the choroid is a congenital defect due to imperfect closure of the choroidal fissure and hence situated in the lower part of the choroid; the white color of the sclera shows through the cleft when the interior of the eye is examined.

The Ciliary Body.—This part of the uveal tract forms a zone surrounding the periphery of the iris and of the lens and underlying part of the sclera. It consists of three zones, the *ciliary muscle*, the *ciliary ring*, and the *ciliary processes*. In meridional section it appears triangular, the base of the triangle looking toward the periphery of the iris, while its outer side is parallel with the sclera. This may be examined with a lens on the sagittal section, though of course not satisfactorily.

The **ciliary ring, orbiculus ciliaris,** although a zone 4 mm. in width, is scarcely demonstrable by gross dissection.

The **ciliary muscle** makes up a considerable portion of the bulk of the ciliary body with the *radial*, *circular* and *meridional fibres*, the distinctions between which are proper objects of microscopic study. The

Fig. 262.—Uveal tract, drawn from human eye previously injected with 5 per cent. formalin. The anterior portion of the sclera and the cornea have been removed and the posterior portion of the sclera turned backward from an equatorial incision.

meridional fibres, the **tensor choroidea,** have been referred to as being attached to the sclera near the margin of the cornea; passing backward they become continuous with the choroid, which they are thus enabled to draw forward as a part of the act of accommodation.

The **ciliary processes** (Fig. 263) are sixty to seventy radial plications, highly vascular, passing from the inner anterior angle of the ciliary body to the periphery of the lens. Their *posterior aspect* may be demonstrated by removing the lens and the anterior part of the vitreous from the equatorially cut eyeball; their *anterior aspect* is to be seen by cutting away the iris, after it has been examined, from the specimen from which the fibrous tunic has been removed.

Owing to the great vascularity of the ciliary body it readily becomes inflamed (cyclitis) as the result of traumatism, the inflammation often spreading to the iris (irido-cyclitis) or to the entire globe (pan-ophthalmitis). Hence the ciliary region is called the "danger-zone."

The Iris.—The iris, the most anterior part of the vascular tunic, is a circular curtain placed in front of the lens imperfectly separating the *anterior* and *posterior chambers*. In an uncut eyeball, remove the cornea by a circular cut near its margin, which opens the anterior chamber and allows the aqueous humor to escape. The anterior surface of the iris, covered with endothelial cells, is now exposed. The anterior elastic lamina of the iris is continuous with the posterior elastic lamina of the cornea at the angle of approximation of the latter with the iris, the *outer angle* of the anterior chamber, or the **filtration angle.** At the moment of passing from the cornea to the iris, the membrane breaks up into irregular bands which collectively constitute a ring, the **ligamentum pectinatum iridis,** the spaces within which are the **spaces of Fontana.**

The **pupil,** the perforation in the iris, is circular in man but transversely elongated in the eye of the ox.

Note the radial striation of the iris, well seen in one's own eye with a concave mirror, and the **circulus iridis major** near its periphery, an

FIG. 263.—Ciliary process seen from in front, exposed by removal of iris. Human eye, formalin preparation. Compare with Fig. 264A.

arterial circle formed by the branches of the anterior and the long posterior ciliary arteries. Radially directed branches from this greater circle form the **circulus iridis minor,** indicated by a ridge concentric with and near the pupillary margin. The variations in the size of the pupil are brought about by the *circular muscular fibres* (sphincter pupillæ), innervated by the oculo-motor nerve (p. 425) and by the *radial fibres* dilatator pupillæ), supplied by the sympathetic.

Note the close relation between the iris and the anterior surface of the lens, on account of which a mydriatic, such as atropin, is used in iritis to prevent *posterior synechia* or inflammatory adhesion of the iris to the lens. *Coloboma of the iris* may occur in association with coloboma of the choroid, presenting as a cleft, usually in the lower part of the iris.

The **anterior chamber** has been sufficiently defined and its filtration angle and contained aqueous humor have been mentioned. It re-

mains to note the importance of the humor and of the filtration angle. The presence of the aqueous and of the fluids of the eye generally is of such consequence to the integrity of the organ that the escape of any considerable proportion of fluid after a punctured wound is disastrous. On the other hand, the normal drainage of the aqueous through the spaces of Fontana at the filtration angle into the lymph-spaces of the sclera is equally important, any interference with such drainage causing increased intraocular tension with consequent damage to the various tissues of the organ and especially to the retina. This condition is seen in **glaucoma,** the signs of which, as pain, bulging of the cornea, increased tension, failure of vision, are directly traceable to pressure. Since mydriatics, by causing the iris to contract toward its periphery, block the filtration angle, their use is contraindicated in any case of increased intraocular tension.

The Retina.—The third or nervous tunic of the eye, the retina, consists of an outer **pigmented layer** derived from the superficial layer of the optic cup, and the delicate transparent **nervous layer** resulting from the deep or invaginated layer of the cup. Though apparently terminating at the *ora serrata*, at the posterior limit of the ciliary body, it extends forward in atrophic form to the margin of the pupil. Three parts are therefore recognized, the **pars optica,** corresponding with the extent of the choroid, the **pars ciliaris,** which is on the inner surface of the ciliary body, and the **pars iridica retinæ,** or that part in relation with the posterior surface of the iris (Fig. 264 A).

The outer surface of the retina may be exposed by cautiously stripping away the choroid in fragments in the specimen in which the choroid has been exposed. The inner surface may be seen in any of the cut specimens, by gently shaking out the vitreous. The nervous layer of the retina is apt to be dislodged also by this procedure and will be seen to be attached at the **optic papilla** or point of exit of the optic nerve-fibres. Examination of the formalin eye from the cadaver—the uveal tract and retina of which should be divided by an equatorial cut with the scissors—will reveal the **macula lutea,** the part of the retina concerned with direct vision, upon the temporal side of the optic papilla. The macula, not present in the bovine retina, is at the posterior end of the optic axis. In the same specimen, branches of the **central artery of the retina** will be seen radiating, chiefly upward and downward, from the region of the papilla. These parts of the retina are best seen in the living subject by the use of the ophthalmoscope (Fig. 264 B).

The neural layer of the retina is transparent in life and so offers no obstruction to the rays of light which traverse the refractive media and impinge upon the pigment layer. *Retinitis*, occurring especially in constitutional conditions such as nephritis and diabetes, is made evident by cloudiness or opacity of the retina. *Detachment of the retina* sometimes results from traumatism. The retinal arteries are

liable to *hemorrhage.* The **optic papilla** is subject to change as the result of intracranial pressure; thus brain-tumors may produce *choked disk.*

The pigment of the retina, present in the ciliary and iridal portions as well as in the ocular part, and the pigment of the uveal tract may be absent, constituting the condition known as *albinism.* The eyes of such subjects appear "pink" because of the lighting up of the interior by the light which is permitted to pass through the tunics of the globe.

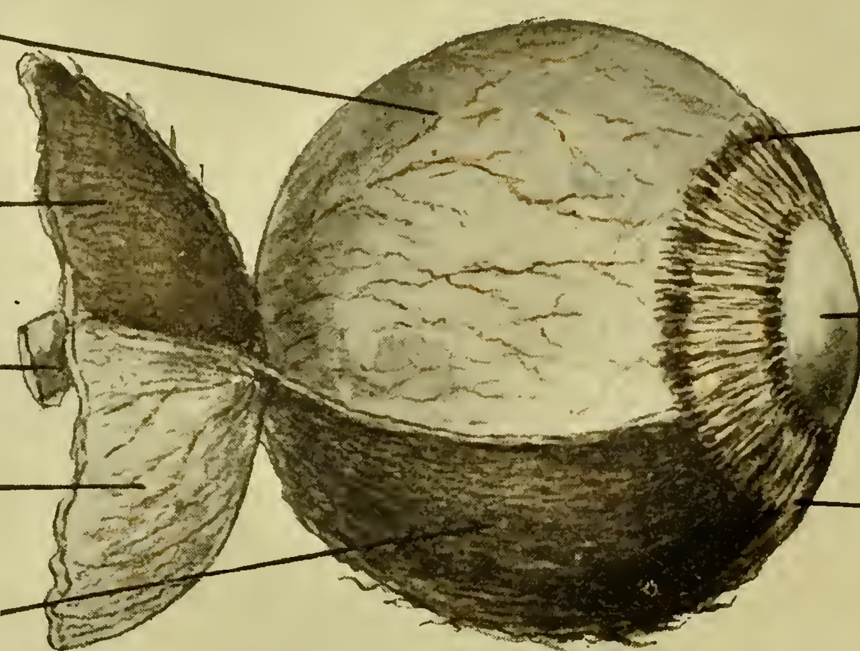

Fig. 264A.—Pars optica of retina, outer surface. The pigment layer of the retina has been reflected with the choroid in the upper half of the globe, exposing the nervous layer. Human eye, formalin preparation, enlarged.

Fig. 264B.—Inner surface of retina, posterior portion, showing macula lutea and optic papilla with retinal vessels radiating from the latter. Human eye, formalin preparation.

The Vitreous Body and the Crystalline Lens.—The vitreous and the lens are to be dislodged from an eyeball after making an equatorial section with scissors through all the tunics in the manner previously indicated for dividing the sclera. The close relation between the lens and the vitreous will be apparent, the **patellar fossa** on the front surface of the latter accommodating the lens (Fig. 261).

The Vitreous.—It will be seen that the vitreous, notwithstanding its softness and apparent fluidity, has a degree of coherence; this is due to the delicate frame-work, the **hyaloid membrane,** the meshes of which may be demonstrated after a fashion by inflation with air. The hyaloid membrane is prolonged in front to the margin of the lens as the **sus-pensory ligament of the lens,** or the **zonule of Zinn.** The latter consists of bands or processes attached with irregular alternation to the anterior and posterior surfaces of the lens. The **canal of Petit,** the series of spaces enclosed by the zonule, may be demonstrated by inflation with air through several punctures close to the lens margin.

Floating particles in the vitreous, which are seen by the patient as specks before the eye, are known as *muscæ volitantes.*

The Crystalline Lens.—The lens, the principal refractive medium of the eye, is enclosed in a **capsule** and is related to the vitreous as indicated above. It may now be detached and placed in dilute alcohol, when the layers of which it is composed and their peculiarly arranged lines of separation will become evident. If it be now compressed and rubbed between the fingers the distinction between the softer **cortical part** and the more firm **nucleus** will be apparent.

Opacity of the lens constitutes **cataract,** which may be *capsular, lenticular* or *lentico-capsular,* according to the part affected. The lens is sometimes *dislocated.*

CHAPTER IV

THE ABDOMEN AND THORAX

THE MALE PERINEUM.

For the dissection of the perineum, the body is to be placed in the lithotomy position (Fig. 265), a steel sound, well lubricated, having been first passed cautiously into the urethra, preceded by the injection of about six fluid ounces of water into the bladder.

The **boundaries of the inferior opening of the pelvis** should be studied on the bony pelvis: the tip of the coccyx and the symphysis pubis being respectively the *posterior* and *anterior limits*, while the *lateral boundaries of the anterior half* are the tubera and rami of the ischia and the vertical rami of the pubes; the *lateral boundaries of the posterior half* are the greater sacro-sciatic ligaments. The structures filling in this space constitute the **perineum**—though this term is often restricted to the anterior part of the region—and corresponds to the floor of the pelvic cavity. The anterior part of the pelvic floor is formed by the triangular ligament, the part back of this by the levatores ani, while the most posterior part of the floor is formed by the coccygei muscles (Fig. 270).

THE SURFACE ANATOMY.

The lozenge-shaped outline of the perineum may be defined by palpation, which elicits as its **boundaries** the bones and ligaments detailed above as the boundaries of the pelvic outlet supplemented in the posterior half by the borders of the glutei maximi. The **perineum** is divided by an imaginary line, convex forward, connecting the ischial tuberosities, into an *anterior portion*, the *perineum proper* or the *urethral* or *urogenital triangle*, and a *posterior part*, the *ischio-rectal region* or *anal triangle*.

The **anus** is in about the centre of the space and presents a puckered margin due to the *corrugator cutis ani* muscle. The junction of the skin with the mucous membrane is sometimes called the *white line of the anus*.

The delicacy of the skin of the anal region is such that it is easily abraded, thus opening a way for infection, which may result in **boils** or **abscesses.** The absence of external support favors the development of **external hemorrhoids.** Abrasion or irritation of the mucous membrane at the anal margin may produce an ulcer, **anal fissure,** which is peculiarly painful and intractable because of the movements of the anal sphincter muscle. Hence, the temporary paralysis of the sphincter by overstretching and the division of some of its fibres for the cure of the fissure. **Imperforate anus** is the persistence of the anal membrane of fetal life, which normally disappears in the fourth fetal month.

The **rectum** should be explored with the finger protected by a rubber finger-cot. In the living subject, the entrance of the finger is re-

sisted by the contraction of the **internal sphincter** which surrounds the last inch of the bowel, the **anal canal** or **second part of the rectum,** and is to be overcome by a voluntary bearing-down effort. The longitudinal folds of the anal canal, the **columns of Morgagni,** are to be noted, as well as the widening of the tube into the **ampulla,** the lower part of the first portion of the bowel, above the anal canal. The transverse shelf-like folds projecting into the lumen, the so-called valves of the rectum

Fig. 265.—Cadaver in lithotomy position; incision for dissecting perineum.

(p. 689), may be recognized, the lowest being about two inches above the anus. Directing the finger upward and forward, the **prostate** is perceived and its size may be noted. Posteriorly the **tip of the coccyx** may be felt.

In the anterior part of the space, the urethral triangle, pressure along the mid-line detects the **bulb of the spongy body.** The **raphe** is a linear median marking extending from the margin of the anus to the scrotum and from the coccyx to the anus.

Cleft perineum, a median fissure, is a congenital defect, often associated with hypospadius, due to imperfect union of the margins of the genital fissure.

THE DISSECTION OF THE ISCHIO-RECTAL REGION.

The rectum should be packed with gauze or cotton—but not over-distended—and the margins of the anus stitched; the hair should be clipped or shaved off.

A median incision is to be made from the base of the scrotum to the tip of the coccyx, interrupted at the anus by a circular cut, and a trans-

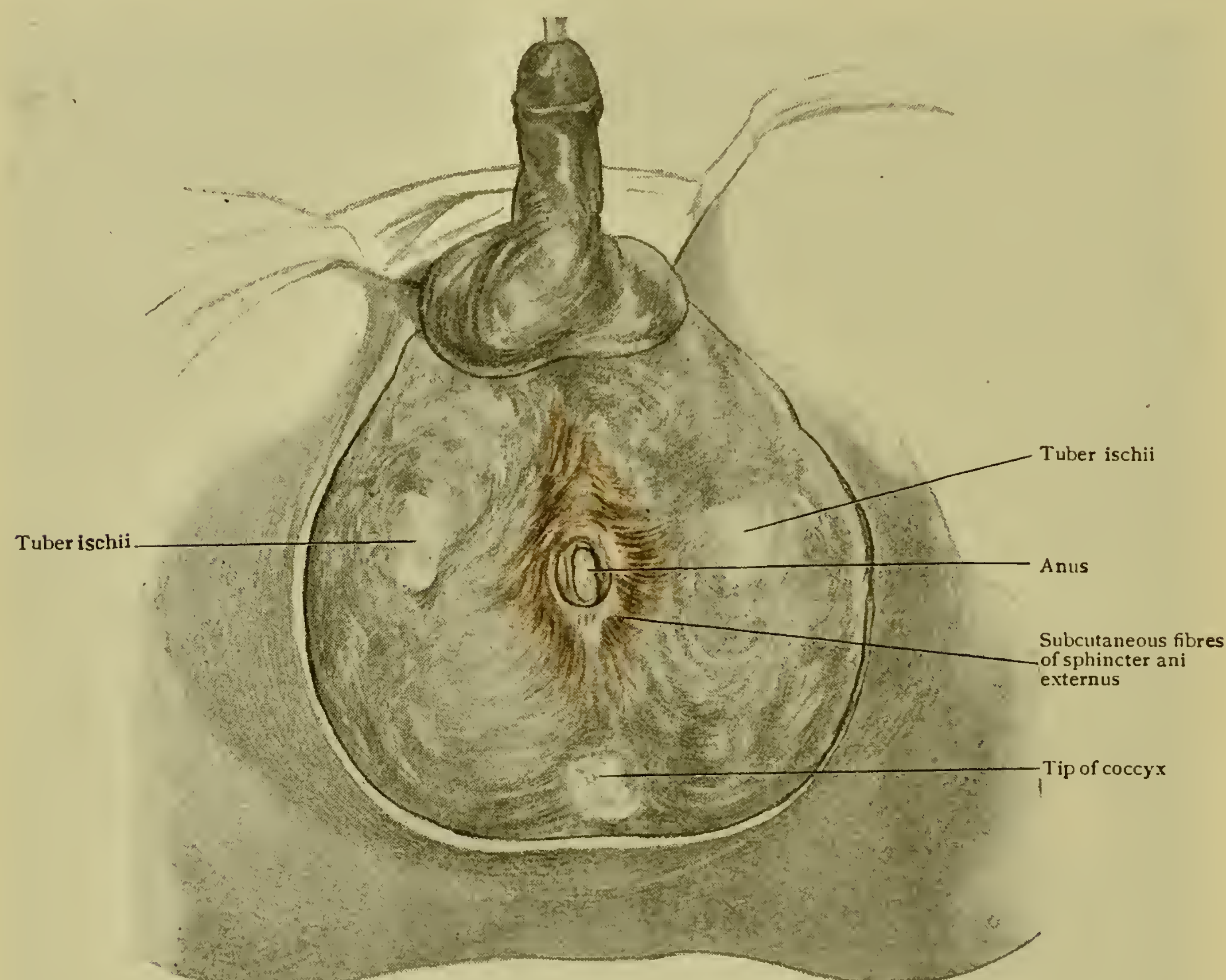

FIG. 266.—The superficial fascia of the perineum.

verse incision just in front of the tubera ischii. The reflection of the skin-flaps exposes the superficial fascia of both the urethral and the anal triangles.

The **external sphincter** (m. sphincter ani externus) is also exposed by the removal of the skin. Its **attachments** are, behind, the tip of the coccyx, in front, the tendinous centre of the perineum. It is a flat plane of voluntary muscle whose fibres encircle the anal aperture and are adherent to the skin (Fig. 267). It is **innervated** by the fourth sacral and inferior hemorrhoidal nerves.

THE SUPERFICIAL FASCIA.—The superficial fascia of the ischio-rectal region is thick and loaded with fat, in marked contrast to the thinness

and delicacy of that of the urethral triangle. It is continuous with the fascia of the buttocks and its fatty masses project into two deep depressions beside the rectum, the *ischio-rectal fossæ* (Fig. 268).

The **nerves** to be found here are a *branch of the fourth sacral* near the back part of the space (Fig. 268), the *inferior hemorrhoidal nerves* from the pudic, crossing the posterior half of the fossa from the lateral margin, and some *cutaneous branches of the perineal division of the pudic nerve* in the front of the fossa. There are also some small trunks connecting these nerves with the inferior pudendal nerve (p. 183). These nerves should be sought in the localities indicated, except the inferior hemorrhoidal; these are deeply embedded in the fat of the fossa, which latter must be pulled out piecemeal. These various nerves supply the skin of the region and the external sphincter, converging generally toward the anus.

The **inferior hemorrhoidal arteries** are a group of small branches of the internal pudic artery (Fig. 267); they are closely intertwined with the inferior hemorrhoidal nerves and pursue the same course.

After the recognition of these nerves and vessels, a median incision may be made through the superficial layer of the superficial fascia of the anterior or urethral triangle. This fascia should be raised on either side of the mid-line just sufficiently to show its continuity with the superficial fascia of the ischio-rectal region, when it may be divided from the latter by a transverse cut.

The Ischio-Rectal Fossa.—Having removed the fat and loose cellular tissue from these fossæ, note their depth and the convergence of their lateral walls toward each other as they recede from the surface. The **outer wall** is formed by the lower part of the obturator internus muscle covered by the obturator fascia; the **inner wall,** by the levator ani muscle covered by the anal fascia, supplemented behind by the coccygeus muscle. To understand these relations one must take note of the pelvic fascia and of the muscles concerned. The **obturator internus muscle** (p. 695) covers a large part of the inner surface of the lateral wall of the pelvis (Fig. 87). The **pelvic fascia** covers the upper part of the muscle (Fig. 336) and may be said to leave the muscle at the level of a line extending from the spine of the ischium to the posterior surface of the body of the pubis, along which line it presents a thickening, the *white line;* or, according to another conception, the fascia splits into two layers along this line. The *outer layer* continues downward over the lower part of the internal obturator muscle, as the **obturator fascia,** to acquire attachment to the tuberosity and ramus of the ischium and the lower ramus of the pubis. Since the levator ani arises in part from the white line, the latter is called the *arcus tendineus musculi levatoris ani.* The *inner layer* of the pelvic fascia, or the continuation of it, according to one's view-point, extends inward upon the pelvic surface of the leva-

tor ani (p. 565). A *third layer of fascia*, the **anal fascia,** passes downward and inward from the white line over the inferior surface of the levator ani. The levator ani and the obturator internus, diverging from each other at the white line, form, therefore, the two sides of a triangle as seen in coronal section, the base of which corresponds with the cutaneous surface of the ischio-rectal fossa (Fig. 332).

The **outer wall of the fossa,** constituted as above indicated, presents the *internal pudic artery* and *veins* and the *pudic nerve*, enclosed in the

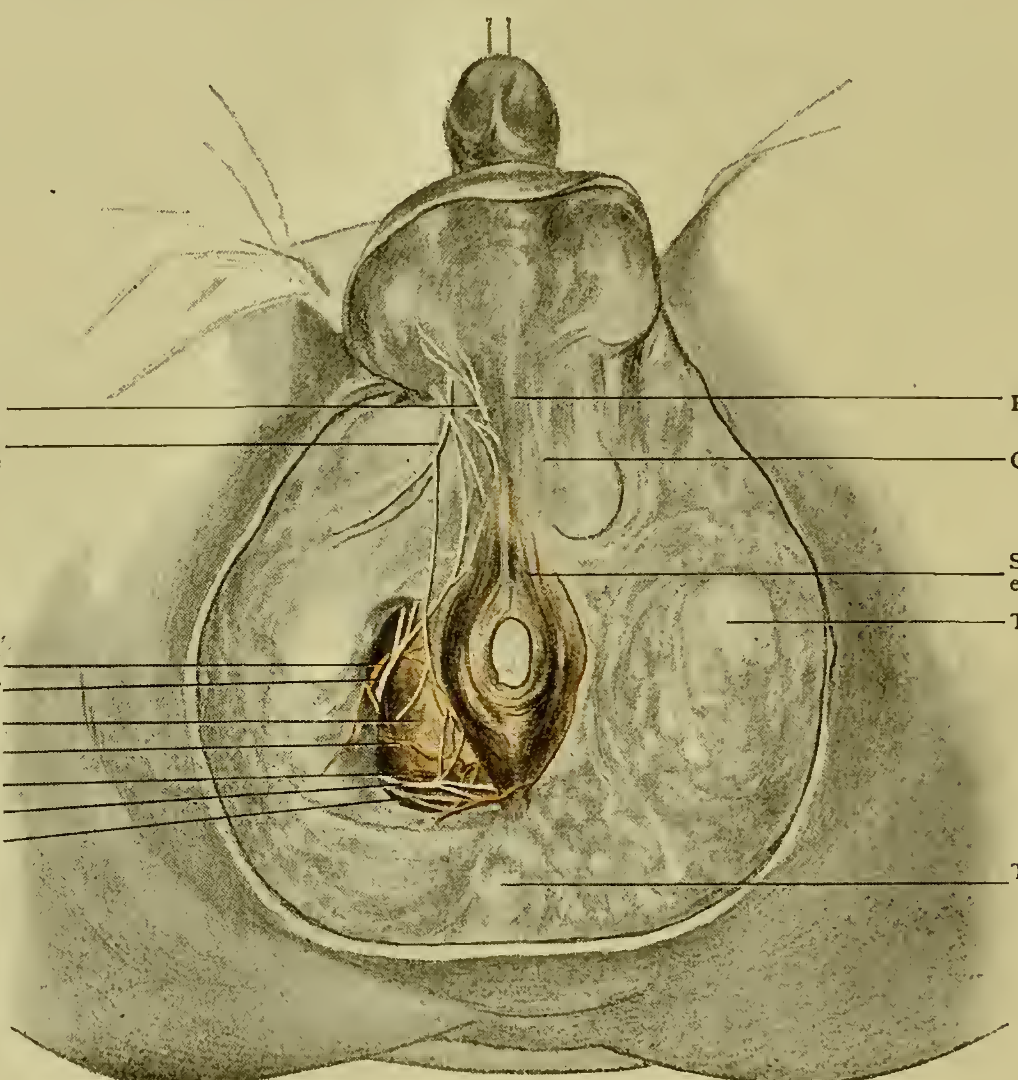

Fig. 267.—Dissection of perineum; right ischio-rectal fossa exposed; Colles's fascia of left side exposed.

canal of Alcock, a fascial sheath derived from the obturator fascia. This canal, an inch and a half to two inches from the level of the tuberosity of the ischium, should now be opened and the contained structures isolated.

The **pudic nerve** (n. pudendus), a branch of the pudendal plexus (p. 697), enters the fossa through the lesser sacro-sciatic foramen. Its **branches** are the *inferior hemorrhoidal* (p. 563) and, in the fore part of the fossa, the *terminal branches*, the *perineal* and the *dorsal nerve of the penis;* the latter nerve leaves the ischio-rectal fossa in front to enter the deep perineal interspace (p. 569). The **perineal nerve** divides into the *superficial* or *cutaneous*—the *anterior* or *internal* and the *posterior* or *external*

superficial perineal—and the *deep* or *muscular*. These branches will be followed in dissecting the urethral triangle, except the few muscular branches that go to the external sphincter of the anus and the levator ani, which have already been dissected.

The **internal pudic artery** (a. pudenda interna) (origin and course p. 693) enters the fossa through the sacro-sciatic foramen to pursue the course indicated above. Of its **branches,** the *inferior hemorrhoidal,* arising as a single trunk or as two near the back part of the fossa, have been dissected. At the fore part of the fossa, the *superficial perineal artery* arises and will be found passing either over or under the transverse perineal muscle to enter the urethral triangle. The internal pudic then pierces the deep layer of the triangular ligament to enter the deep perineal interspace (p. 570).

The internal pudic artery may be wounded in the operation of lateral lithotomy if the incision be carried too near the tuberosity of the ischium.

The obturator fascia may now be detached from the tuberosity of the ischium and separated from the obturator internus, the finger being passed between the fascia and the muscle to demonstrate the continuity of the former with the lateral or parietal part of the pelvic fascia.

The **inner wall of the fossa,** formed as indicated above, should now be examined. The anal fascia should be raised as a layer if possible and followed to the deep part of the fossa at its line of origin from the pelvic fascia. This exposes the levator ani.

Levator Ani (Fig. 270).—**Origin,** the line of thickening of the obturator fascia (the white line, p. 687) and the body of the pubis and the spine of the ischium at the respective extremities of this line; **insertion,** upon the tip and sides of the coccyx and the median raphe running from the coccyx to the anus, and upon the sides of the rectum; **nerve-supply,** the third and fourth sacral (Fig. 336) and the inferior hemorrhoidal nerves; **action,** to flex the coccyx and to raise the pelvic floor.

The levator ani not infrequently presents several intervals between its bundles, through which the pelvic fascia is seen. Its posterior border may be so closely related to the coccygeus that the two muscles, the so-called *pelvic diaphragm,* appear as one, or there may be a distinct interval between them.

Coccygeus (Fig. 87).—**Origin**, the spine of the ischium; **insertion,** the side of the sacrum and of the coccyx; **nerve-supply,** the third and fourth sacral nerves; **action,** lateral flexion of the coccyx and elevation of the pelvic floor.

The fat of the ischio-rectal fossa being rather poorly supplied with blood falls an easy prey to infections. The pus in ischio-rectal abscess does not readily find its way to the surface, but, following the direction of least resistance, burrows upward along the rectum, into which it usually is discharged. The almost constant motion of the pelvic diaphragm and of the sphincter interferes with the obliteration

of the pus tract, the resulting sinus constituting a **fistula in ano.** An *incomplete internal fistula* is one with an opening into the bowel; an *incomplete external fistula* is one with an external opening; a *complete fistula* is one with an internal and an external opening.

THE DISSECTION OF THE UROGENITAL TRIANGLE.

The *surface anatomy*, the *skin* and in part the *superficial layer of the superficial fascia* have already been dealt with.

The **inferior** pudendal nerve (rr. perineales of the small sciatic) (p. 183) should be sought at the outer side of and distal to the tuberosity of the ischium where it pierces the deep fascia (Fig. 267). If not readily found here, no time need be spent in searching for it, as it will be encountered after the reflection of Colles's fascia. It supplies *cutaneous branches* to the proximal part of the penis, the scrotum and the anus. Some of these branches, as well as branches of communication with the inferior hemorrhoidal and the superficial perineal nerves, should be found in the superficial fascia (Fig. 267); they are sometimes quite conspicuous.

THE SUPERFICIAL FASCIA.—The superficial layer of this fascia should now be reflected beyond the lateral boundaries of the triangle and its continuity in front with the superficial layer of the dartos of the scrotum noted, the skin of the latter being reflected to a slight extent for the purpose.

The **fascia of Colles,** the deep layer of the superficial fascia, is now exposed (Fig. 267). Pinching up a portion of this on one side with the forceps, inject beneath it a quantity of water with the hypodermic syringe and note the limits of the resulting distention. This demonstrates a space, the *superficial perineal interspace*, beneath this fascia, and that the fascia is bound down laterally to the rami of the ischia and pubes, that it dips down behind (to be attached to the superficial layer of the triangular ligament) and that it is continuous in front with the deep layer of the dartos of the scrotum. It is evident, too, that a median septum divides the space into lateral halves. Colles's fascia should now be reflected from a median incision with extreme care to avoid taking up with it the underlying nerves. It should be followed into the scrotum a little way as the deep layer of the dartos, and back to the base of the triangle, each lateral flap then being cut transversely near its posterior margin.

THE SUPERFICIAL PERINEAL INTERSPACE (Fig. 268).—This space is bounded superficially by Colles' fascia as just seen and deeply by the anterior layer of the triangular ligament. It is now seen to consist of two muscular triangles placed side by side.

The **bulbo-cavernosus muscle** or **accelerator urinæ** (Fig. 268), with its fellow, divides the space into lateral halves. Its **origin** is the central tendon of the perineum and the median raphe between the two muscles.

The *posterior fibres*, almost covering one lateral half of the bulb, are **in=serted** into the superficial layer of the triangular ligament; the *more anterior fibres* pass around the corpus spongiosum to be inserted into its dorsal surface; the *most anterior fibres* diverge over the corpus cavernosum, and passing around its outer side are inserted into the dorsal surface of the penis. The **nerve of supply,** a branch of the perineal division of the pudic, should be found entering the back part of the muscle.

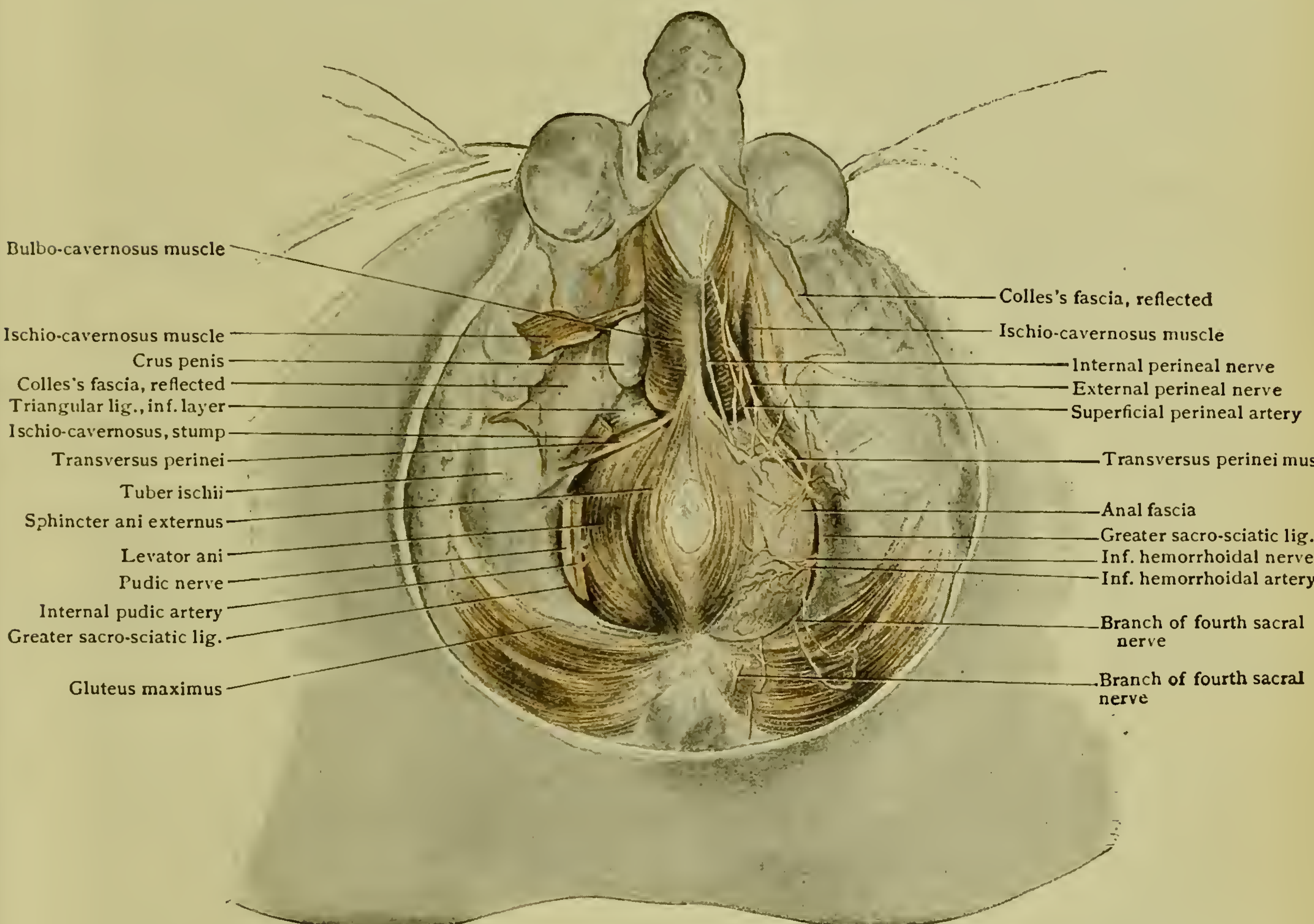

FIG. 268.—Dissection of perineum; Colles's fascia has been cut and reflected to expose crura and bulb of penis covered by muscles; on right side ischio-rectal fossa is partly cleaned out.

The **action** is to expel urine or semen from the urethra and to aid in erection of the penis by compression of the dorsal vein and of the spongy body and its bulb.

The **ischio=cavernous** or **erector penis** (Fig. 268) is found along the lateral margin of the urethral triangle covering the *crus penis* (Fig. 269). Its **origin** is the tuberosity of the ischium; its **insertion,** the lower outer surface of the crus penis where the latter merges into the corpus cavernosum. The **nerve of supply,** from the perineal nerve, will be found near the muscle's origin. The **action** is to aid in erection of the penis.

The **superficial transverse perineal muscle** (Fig. 268) **arises** from the tuberosity of the ischium and is **inserted** into the perineal centre. It may consist of a few scattered fibres or may be absent. Its **nerve-supply** is the perineal; its **action,** to aid in fixing the central tendon of the perineum and so to assist the action of the bulbo-cavernosi.

The **nerves** of the interspace should now be followed (Fig. 268). The **external** or **posterior superficial perineal** and the **internal** or **anterior superficial perineal** (p. 564) pass forward through the small muscular triangle. The former nerve is distributed to the skin of this region; the latter, which is larger, is situated more deeply and enters the space by piercing the back part of its floor, is distributed to the scrotum.

The **muscular branches of the perineal nerve** (p. 567) have been identified in dissecting the muscles.

The **inferior** or **long pudendal nerve** (p. 566) should be found passing along the lateral margin of the space to the outer side of the superficial perineal nerves (Fig. 267).

The **arteries** are the **transverse perineal artery,** which should be traced from its *origin* in either the superficial perineal or the internal pudic to and along the superficial aspect of the transverse perineal muscle toward the perineal centre; and the **superficial perineal,** which should be followed from its *origin* in the internal pudic in the ischio-rectal fossa, through the base of the triangular ligament into the superficial perineal interspace, and then forward with the superficial perineal nerves. The *branches* of the superficial perineal artery should be noted as going to the muscles of the space and to the scrotum.

The ischio-cavernosus should now be detached from the crus penis and reflected forward and the crus of one side may also be detached from the bone. The bulbo-cavernosus should be carefully removed from the corpus spongiosum and its bulb. The transverse perineal muscles and the vessels and nerves of the space may also be removed.

The **floor of the superficial interspace** is now fairly well exposed. It is a strong membrane, the **triangular ligament** or **anterior layer of the triangular ligament,** which stretches between the rami of the ischia and pubes of the two sides. Displacing the crus penis at the anterior part of the space, the **artery of the corpus cavernosum** and the **dorsal artery of the penis,** the two terminal branches of the internal pudic, will be seen piercing the ligament with the dorsal nerve of the penis. The **dorsal vein** of the penis will be seen to pierce the ligament close to the symphysis pubis upon slightly displacing the spongy body. Now draw the bulb a little to one side, loosening somewhat its membranous connection with the ligament, and note the **urethra** piercing the latter to enter the spongy body; on each side of the urethra, the **duct of Cowper's gland** perforates the ligament.

In extravasation of urine into the superficial perineal interspace from rupture of the spongy portion of the urethra, the fluid makes its way into the scrotum, since this space is closed at the sides and behind by the attachments of Colles's fascia but is open in front because of the continuity of this fascia with the dartos (superficial fascia) of the scrotum (p. 566).

Because of the strength and firmness of the superficial layer of the triangular ligament, the margin of the opening in it traversed by the urethra may catch the tip of a catheter or sound during the introduction of these instruments, or may arrest the shoulder of a bulbous bougie as the latter is withdrawn from the deep urethra, and so may simulate a urethral stricture.

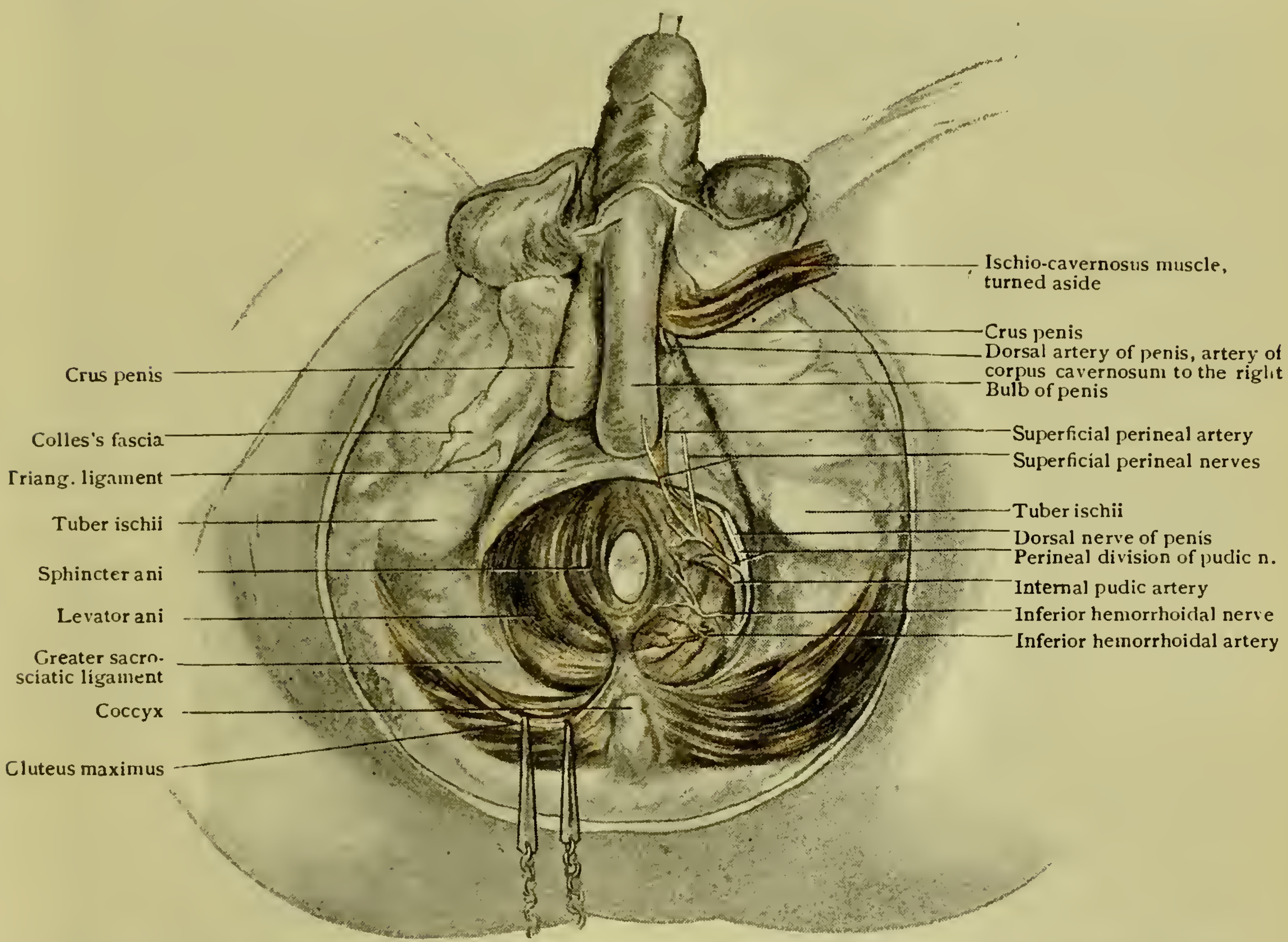

Fig. 269.—Dissection of perineum, showing inferior layer of triangular ligament and inner wall of ischio-rectal fossa partially exposed.

The Deep Perineal Interspace.—This space will be exposed by removing the superficial layer of the triangular ligament, which should be done on one side only.

The **compressor urethræ muscle** and back of it the **deep transverse perineal muscle** are now seen as a sheet which more or less completely covers the floor of this space. Both **arise** from the ramus of the ischium and are **inserted** into a median raphe in common with the muscles of the opposite side, some of the fibres passing in front of the urethra and some behind it. The *posterior fibres* of the deep transverse perineal muscle pass to the central perineal tendon. The **nerve-supply** is from the perineal nerve. The **action** is to compress the urethra.

Spasmodic contraction of these muscles offers resistance to the passage of a catheter or sound through the membranous urethra.

Cowper's glands (glandulæ bulbo-urethrales) (Fig. 270) will be found one on each side of the urethra and close to it, under the compressor urethræ muscle, which must be raised or cut to expose them. They are the size of a pea. Their *ducts* pierce the anterior layer of the triangular ligament to open into the spongy urethra.

Inflammation of these glands, *Cowperitis*, is usually due to gonorrhœal infection. The denseness of the triangular ligament masks the local signs of inflammation.

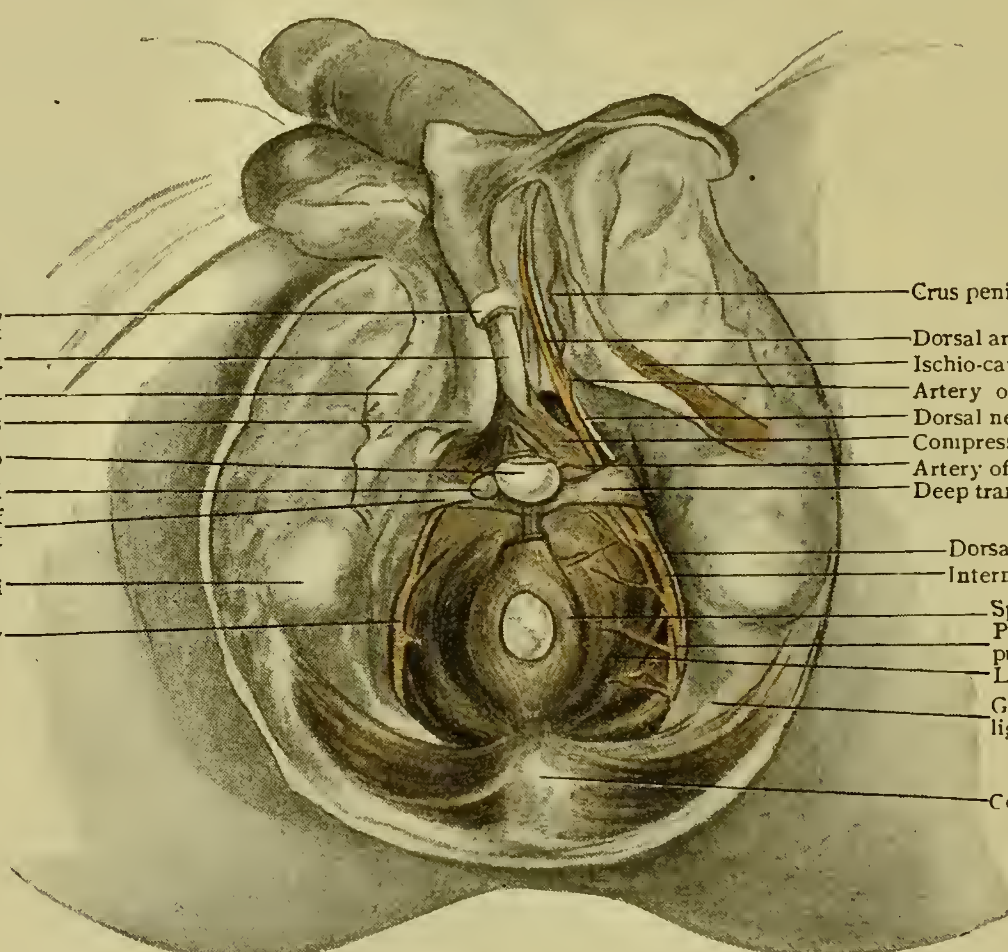

Fig. 270.—Dissection of perineum, in which inferior layer of triangular ligament and corpus spongiosum have been partially removed, exposing urethra, covered by compressor urethræ muscle, and Cowper's gland.

The **internal pudic artery** and the **dorsal nerve of the penis** should now be followed from the back of the space, where they pierce the deep layer of the ligament, forward along the lateral margin, the muscular fibres which may cover them being divided. The nerve and the dorsal artery of the penis will be followed in the final stage of their course in the dissection of the penis (p. 620).

The **artery of the bulb** (Fig. 270), a large vessel, is to be traced from its *origin* in the internal pudic at the back part of the space to its destination, the bulb, to reach which the artery perforates the anterior layer of the ligament near the bulb.

The **dorsal vein of the penis** will be found well forward near the pubic arch, where it perforates both layers of the triangular ligament to reach the prostatic venous plexus within the pelvis.

The **floor of the deep interspace,** to be exposed by removing the muscles, vessels and nerves, is constituted by the **deep layer of the triangular ligament,** which is a part of the parietal portion of the pelvic fascia, being directly continuous with the obturator fascia. It differs from the superficial layer of the ligament in being thinner. It blends with the latter at its base, thus closing the deep space.

In rupture of the membranous urethra—that part of this canal between the two layers of the triangular ligament—the urine escapes into this space and remains confined here until ulceration of the tissues opens a way for it into the anal region or into the pelvic cavity.

The Recto-Vesical Space.—To expose the posterior surface of the prostate gland and the lower part of the bladder, cut away the anterior part of the external sphincter and try to define the anterior borders of the levatores ani, pressing the front wall of the rectum backward with the finger. If the anterior borders of the muscles can be reached, the pelvic fascia will appear just in front of them and the muscle fibres may be raised from the fascia and cut (Fig. 272). The lower end of the rectum may now be drawn backward and the pelvic fascia divided on each side parallel with the cuts made through the levator ani (Fig. 272) and reflected. The bladder and prostate are now exposed but not completely, since they are covered by a sheet of fascia, the careful removal of which will reveal the reflection of the peritoneum from the bladder to the rectum.

The Prostate Gland (Fig. 272).—The *posterior surface* of the prostate now exposed is related in the undisturbed condition with the rectum, the *upper surface* or *base* is in contact with the bladder, while the *apex* rests against the deep layer of the triangular ligament. The comparatively loose **sheath,** derived from the visceral layer of the pelvic fascia, should be opened by a median incision and stripped toward either side. Within the sheath, between it and the fibro-muscular **capsule,** is a plexus of veins, the **prostatic plexus** (p. 688), as well as the **arteries,** branches of the inferior vesical and middle hemorrhoidal, which supply the gland. The inseparable connection between the upper surface of the gland and the bladder should be noted and also the emergence of the urethra, which traverses the gland, from its apex. The details of its relation to the urethra will be dealt with later (p. 701). Note the transverse curved fissure, the **incisura,** on the upper part of the posterior surface of the prostate for the entrance of the ejaculatory ducts (*vide infra*).

The **sexual function of the prostate**—its *muscular tissue* aiding in the ejaculation of semen and its *glandular elements* secreting the *prostatic fluid* which serves to dilute the semen—explains its special proneness to *enlargement* after middle life

in those addicted to excessive venery. The terminations of its ducts in the prostatic urethra explain its liability to *gonorrhœal* and other *infections*. The **nerve-supply,** from the fourth sacral nerve through the hypogastric plexus, accounts probably for the lumbar aching incident to *chronic prostatitis*. The relation of the prostate to the urethra determines the pointing of **prostatic abscess** into that channel rather than elsewhere, while, owing to its relation to the rectum, this tube ranks next in order of frequency as the site of rupture of such abscess. The latter relation also is used for diagnostic purposes in prostatic disease. The close relation of the base of the prostate to the bladder, the sheath being absent here, enables the surgeon to shell the gland out of its sheath by going through the bladder wall in the operation of *prostatectomy* by the supra-pubic route.

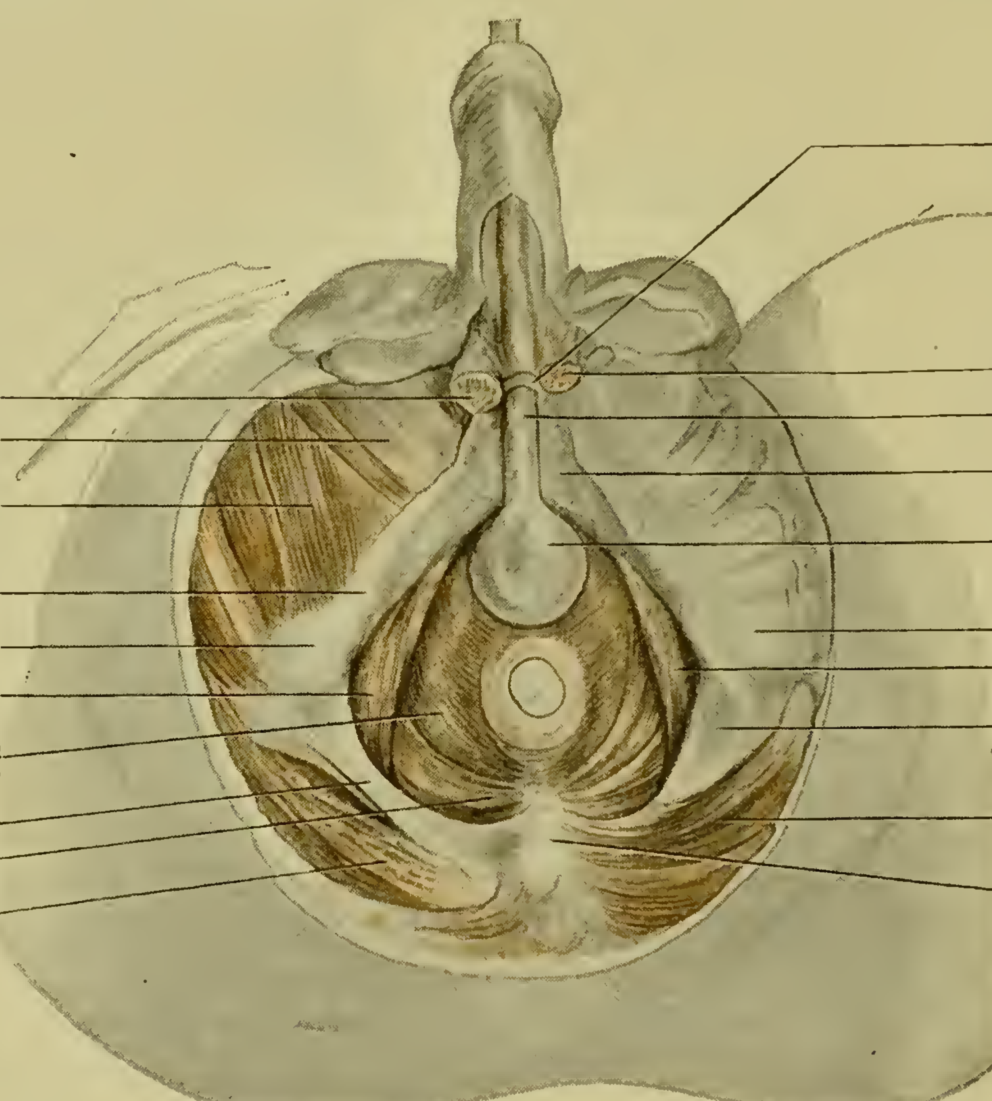

FIG. 271.—Deep dissection of perineum; urethra partially exposed by removal of proximal part of spongy body.

The Vesiculæ Seminales (Fig. 272).—The seminal vesicles, the reservoirs which receive the semen from the testicles through the spermatic ducts or vasa deferentia, form the lateral boundaries of a **triangular space,** of which the *base* is formed by a line along which the recto-vesical fold of the peritoneum becomes connected with the bladder and the *floor* of which is a part of the posterior wall of the bladder. They should now be divested of their **fibro-muscular capsules**—the peritoneum being stripped up from their upper ends—and demonstrated to consist of a convoluted tube with branched diverticula. On the inner side of each

vesicle is the **vas deferens** of the same side, presenting its enlargement or *ampulla*. Tracing the two structures toward the prostate will show that the terminal part of the vesicle, its *duct*, joins the vas, the small common duct thus formed, the *ejaculatory duct*, entering the posterior surface of the prostate through the transverse incision on its way to terminate in the prostatic part of the urethra. The **arteries** supplying the vesicles are from the deferential artery, the inferior vesical and the superior and middle hemorrhoidal (p. 693 and Fig. 334).

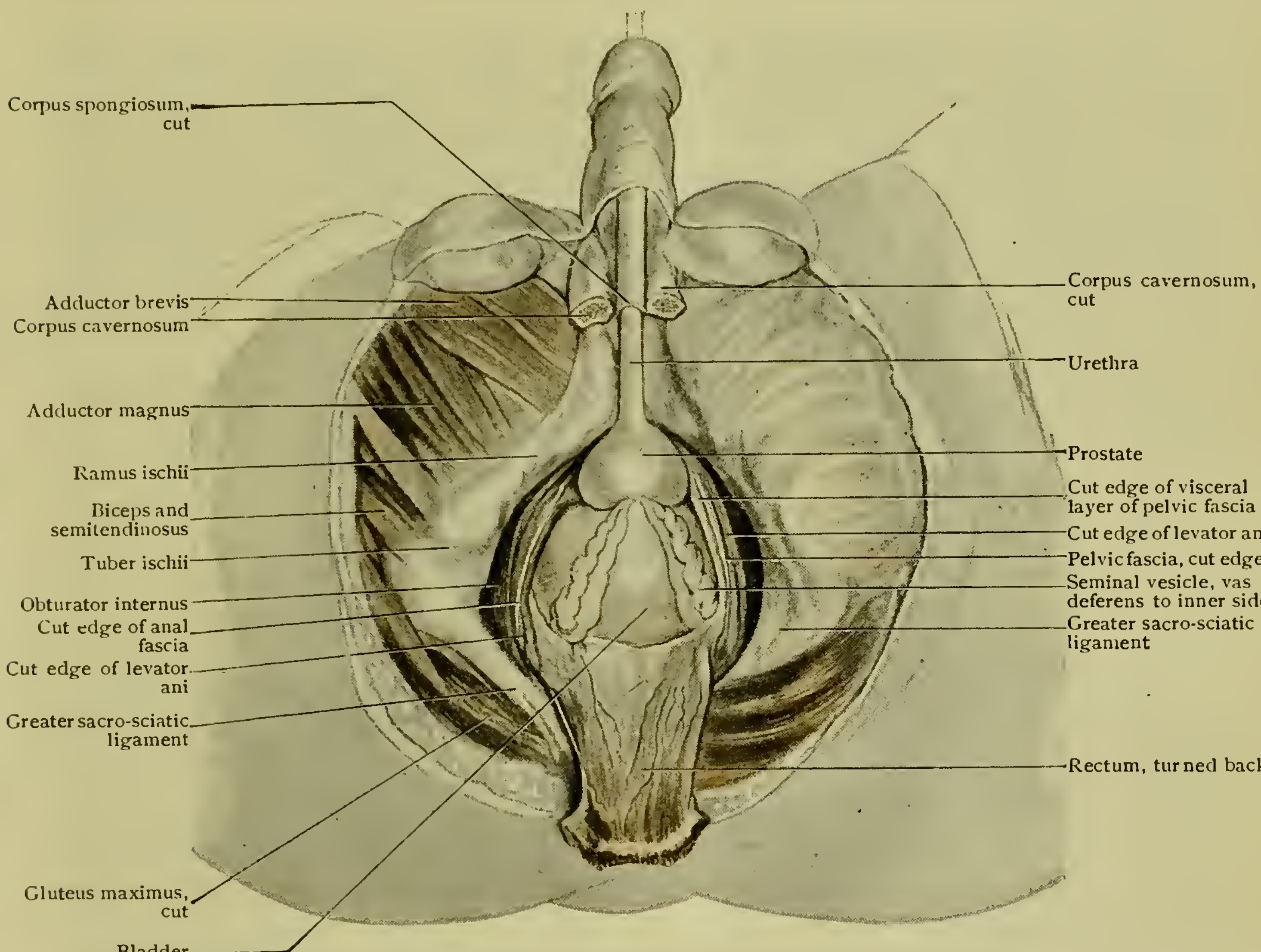

FIG. 272.—Deep dissection of perineum, in which pelvic floor has been partly removed, exposing bladder, seminal vesicles, spermatic ducts, and prostate; rectum has been turned back.

Inflammation of the seminal vesicles, **vesiculitis,** usually due to gonorrhœal infection, may result in *abscess*, the pus sometimes invading the bladder or the peritoneal cavity. Their relation to the rectum makes it possible to apply massage to them with a finger in the rectum and to express their contents in chronic vesiculitis. The triangular area of the bladder wall bounded by the vesicles (Fig. 272), being non-peritoneal, has been selected for puncture through the rectum to draw off the urine in cases of retention.

From the relation of the bladder to the floor of the pelvis and the perineum, it is apparent that **median perineal cystotomy**—or **lithotomy** if done for stone in the bladder—in which the superficial incision begins at the perineal centre, involves the cutting of the perineal centre, the external sphincter, the triangular ligament, the membranous urethra and its muscles, the apex of the prostate and the prostatic urethra.

In **left lateral lithotomy,** the operation preferred when more room is required, the incision is begun just behind the perineal centre and to the left of the mid-line and ends between the anus and the ischial tuberosity, a little nearer to the latter than to the former, cutting the transverse perineal muscle, artery and nerve, the edge of the triangular ligament and the inferior hemorrhoidal vessels and nerves. The membranous urethra and its muscle, the deep layer of the triangular ligament, the anterior fibres of the levator ani and the left lobe of the prostate are cut in the next stage of the operation. Inspection of the parts dissected will demonstrate the structures liable to injury in this operation—the bulb and its artery, the rectum and the internal pudic artery and nerve.

The **corpus spongiosum** and its **bulb** (Fig. 269) and the **crura of the penis** may now be demonstrated to better advantage than has been done by partially distending them with a thin starch mass injected through a hypodermatic needle of large size, several punctures being made in each case. In the injection of the spongy body, the urethra should be avoided. These structures should now be denuded up to their union with each other to form the **penis.** Nothing more is to be done with them at present.

The cadaver is now to be turned for the purpose of dissecting the dorsal region of the trunk (p. 580).

THE FEMALE PERINEUM.

THE SURFACE ANATOMY.

The **boundaries** of this space, elicited by palpation, are as noted on p. 560: a modification presents in the relatively greater width of the space as compared with that of the male (p. 705). What has been said of the **ischio-rectal** or **anal region** of the male applies equally here (p. 560), with the addition that in examination of the rectum, information is to be gained as to the uterus, the ovaries, the cul-de-sac of Douglas and the ureters.

The anterior part of the region, the **urethral** or **urogenital triangle,** presents the external genitalia.

The Female External Genitalia (Fig. 273).—The **vulva** or **pudendum,** the general term for the female external genitals, will be noted as presenting an elongated median fissure, the **urogenital cleft** or **rima pudendi,** flanked on either side by the rounded **labia majora.** These labia are united behind by the *posterior commissure,* in front, by the *anterior commissure* and are continuous here with the *mons Veneris* or *pubis,* the fat-cushioned eminence over the pubic region. Note the dark hue and the hairs on the outer surfaces of the labia, and the similarity in this respect to the scrotum, a lateral half of which each labium majus represents. The more delicate integument and the finer hairs on the inner surfaces are noteworthy.

The **labia minora** or **nymphæ,** two thin delicate cutaneous folds, should be exposed by drawing apart the greater labia. Note the mucous-membrane-like character of their skin, the absence of hair, the manner in which they fade away towards the posterior part of the vulva and their continuity in front with the *prepuce of the clitoris* over the dorsal surface of that organ and with the *frenum* on its under surface. Their posterior extremities are connected, in the virgin, by a transverse fold, the *fourchette,* in front of which is the shallow *navicular fossa* (Fig. 273).

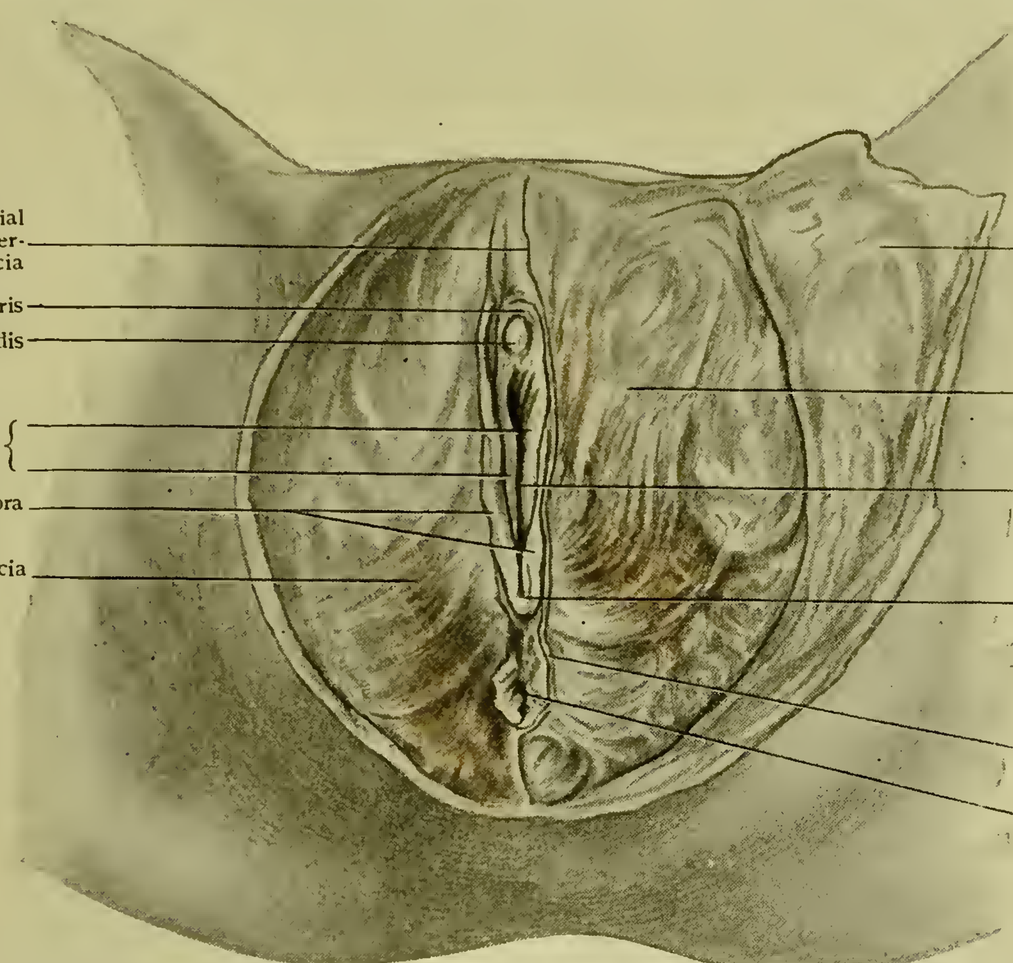

Fig. 273.—Superficial dissection of female perineum; superficial layer of superficial fascia reflected on right side.

The **clitoris,** a rudimentary penis, should be made more evident by grasping its head, the *glans clitoridis,* with forceps and drawing it out from the prepuce (Fig. 274).

The **vestibule of the vagina** is revealed as an elliptical space upon separating the labia minora. The front part of the vestibule is a triangular area, the apex of which is at the clitoris, containing the **meatus urinarius externus,** an aperture of somewhat irregular outline. The term *vestibule* is sometimes restricted to this area. The remaining part of the vestibule includes the *orifice of the vagina,* the *navicular fossa* and the *hymen* when present.

The **hymen,** varying from a mere crescentic fold to a membrane which may occlude the vaginal orifice, is represented in women who have borne children by little excrescences, the *carunculæ myrtiformes* or *hymenales.*

The **orifices of the ducts of Bartholin's glands** should be sought at the side of the vaginal orifice back of its middle and just within the labia minora.

The **female urethra,** an inch and a half in length and quite dilatable as compared with the male urethra, should be explored by passing a female catheter. About six fluidounces of water may be injected through the catheter and the meatus stitched to retain it.

The **vagina,** though not a part of the external genitals, is to be examined in this connection. The finger passed into the vagina notes the inclination of its posterior wall toward the rectum. If the thumb of the same hand or a finger of the other be inserted at the same time into the rectum, it will be evident that the two canals are separated by a wedge-shaped mass of tissue, the base of the wedge being that part of the surface intervening between the anus and the vulva. This mass is the **perineal body,** often called simply the *perineum.* The latter term is also frequently applied to the surface between the anus and the vulva.

The **perineum** or **perineal body** is often torn in child-birth to an extent varying from a superficial laceration to the tearing of the external sphincter ani, the internal sphincter or the entire thickness of the wall of the rectum. **Rectocele** is the pouching into the vagina of the anterior rectal wall permitted by a thinned-out perineal body or a torn one which has not been repaired.

If a speculum be passed into the vagina, it will be noted that the anterior and posterior walls of the canal are in contact before the entrance of the instrument, *i.e.*, that the vagina is a collapsed tube when empty. Its length may also be noted as being three inches along the anterior wall and four inches along the posterior wall, the median ridges, **columnæ rugarum,** on the anterior and posterior walls, and the oblique folds diverging from them, being recognized. Examination through the speculum or with the finger detects the **neck of the uterus** projecting downward and backward into the upper end or **vault** or **fornix** of the vagina (in the erect posture), marked by the **os uteri externum** as a circular aperture in the nulliparous uterus. Behind the os will be found a shorter *posterior lip* and in front of it a longer and thicker *anterior lip.*

THE DISSECTION OF THE ISCHIO-RECTAL REGION.

The rectum is to be moderately distended with gauze strips or tow, and the anus and urogenital fissure closed by stitches, applied, in the latter case, through the inner borders of the labia majora. A median incision from coccyx to anus and from anus to vulva, incisions along the margins of these apertures and a transverse incision connecting the tuberosities of the ischia are required. Reflecting the skin-flaps from the anal triangle, the dissector will proceed according to the directions given at page 562 for the dissection of this region in the male subject.

THE DISSECTION OF THE UROGENITAL TRIANGLE.

Upon the reflection of the skin, the superficial fascia is exposed.

The Superficial Fascia.—The portion of the superficial layer of this fascia pertaining to the labium majus, unlike the dartos of the scrotum, contains a layer of fat, superficial to which is a thin sheet of unstriped muscular fibres. Removing this superficial layer exposes a thin deeper layer which encloses the *central fatty mass* of the labium. In dissecting the upper part of the labium, regard should be had for the *round ligament of the uterus*, which will be found in the dissection of the abdominal wall (p. 602).

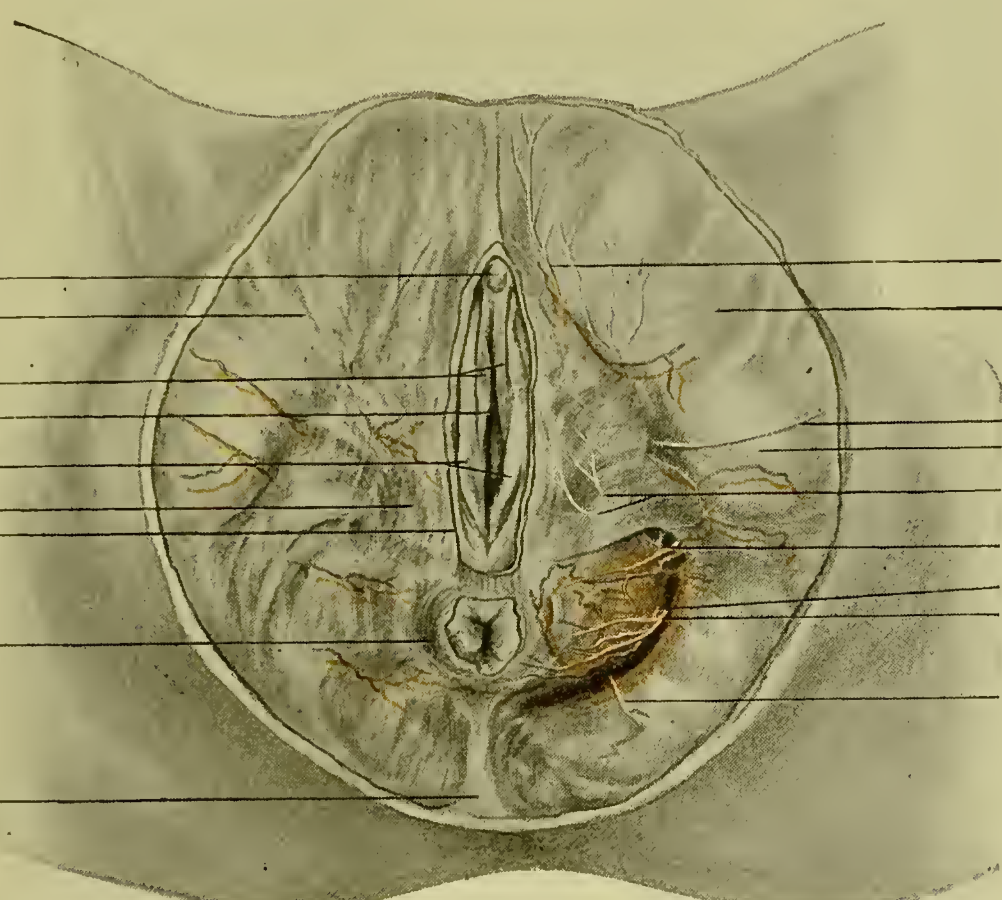

Fig. 274.—Female perineum; deep layer of superficial fascia of urogenital triangle exposed.

Clearing away the remnants of the labia majora will expose the deep layer of the superficial fascia or *Colles's fascia*. In doing this, the branches of the *superficial perineal* and *inferior pudendal nerves* and of the superficial perineal arteries to the labia should be found (Fig. 274).

The **fascia of Colles** in the female (Fig. 274) is less strong than in the male and is perforated by the vagina; otherwise it is like that of the male subject (p. 566). It should be removed to display the structures of the superficial perineal interspace.

The Superficial Perineal Interspace.—This space is bounded like that of the male (p. 566) and contains the corresponding structures or their representatives.

The **sphincter vaginæ** (Fig. 275), which should be isolated, *arises* from the tendinous centre of the perineum and, splitting to embrace the vaginal orifice as it passes forward, is *inserted* into the clitoris, a few fibres sometimes passing to its dorsal surface. It is the representative of the male bulbo-cavernosus, but is cleft by the vaginal orifice.

The **erector clitoridis,** corresponding to the male erector penis and having the same attachments (p. 567), should be denuded and examined.

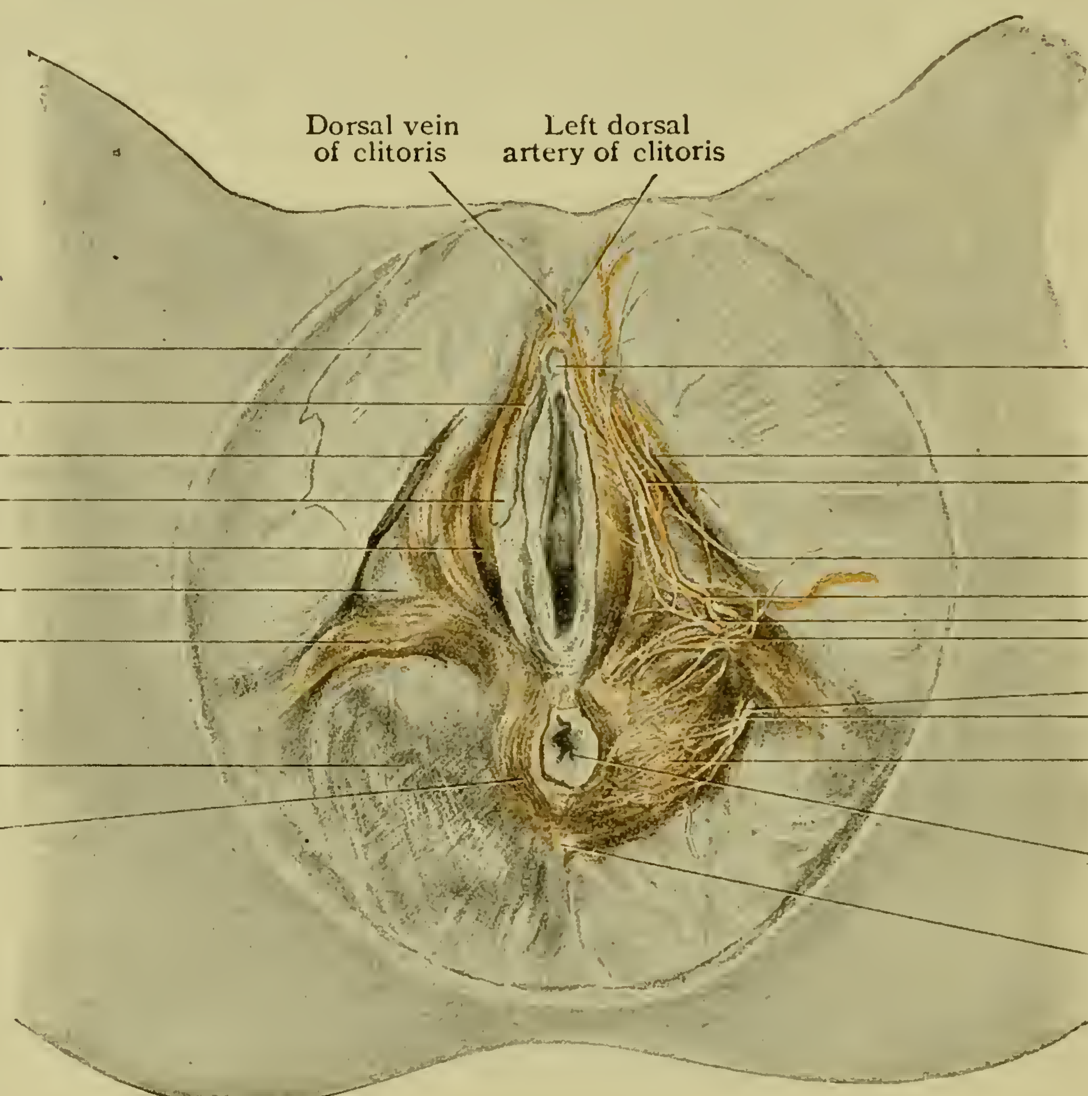

FIG. 275.—Deep layer of superficial (Colles's fascia) removed, exposing structures within superficial interspace.

The **transversus perinei** (p. 568), the **superficial perineal nerves** and **arteries** (p. 568), the **inferior pudendal nerve** (p. 568) and the **muscular branches of the perineal nerve,** pursuing the same course as in the male, should be followed in succession, and should then be removed, the erector clitoridis being raised cautiously from the subjacent *crus clitoridis.* In like manner the two parts of the sphincter vaginæ are to be detached from the underlying bulbs.

The **bulbi vestibuli,** or the **hemi=bulbs,** since each one represents a lateral half of the male bulb of the spongy body, should be examined after the removal of the vaginal sphincter. Like the male bulb it is erec-

tile, being composed of cavernous tissue. An attempt may be made to distend it by injection through the hypodermatic needle (p. 574). Traced forward, each bulb will be seen to be continuous with a venous plexus between the urethra and the clitoris, the **pars intermedia,** which represents part of the corpus spongiosum of the penis and which is therefore in continuity with the glans clitoridis. In other words, the male corpus spongiosum, which enlarges in front to form the glans penis and behind to form the bulb, is represented in the female by the glans clitoridis, the pars intermedia and the two bulbi vestibuli.

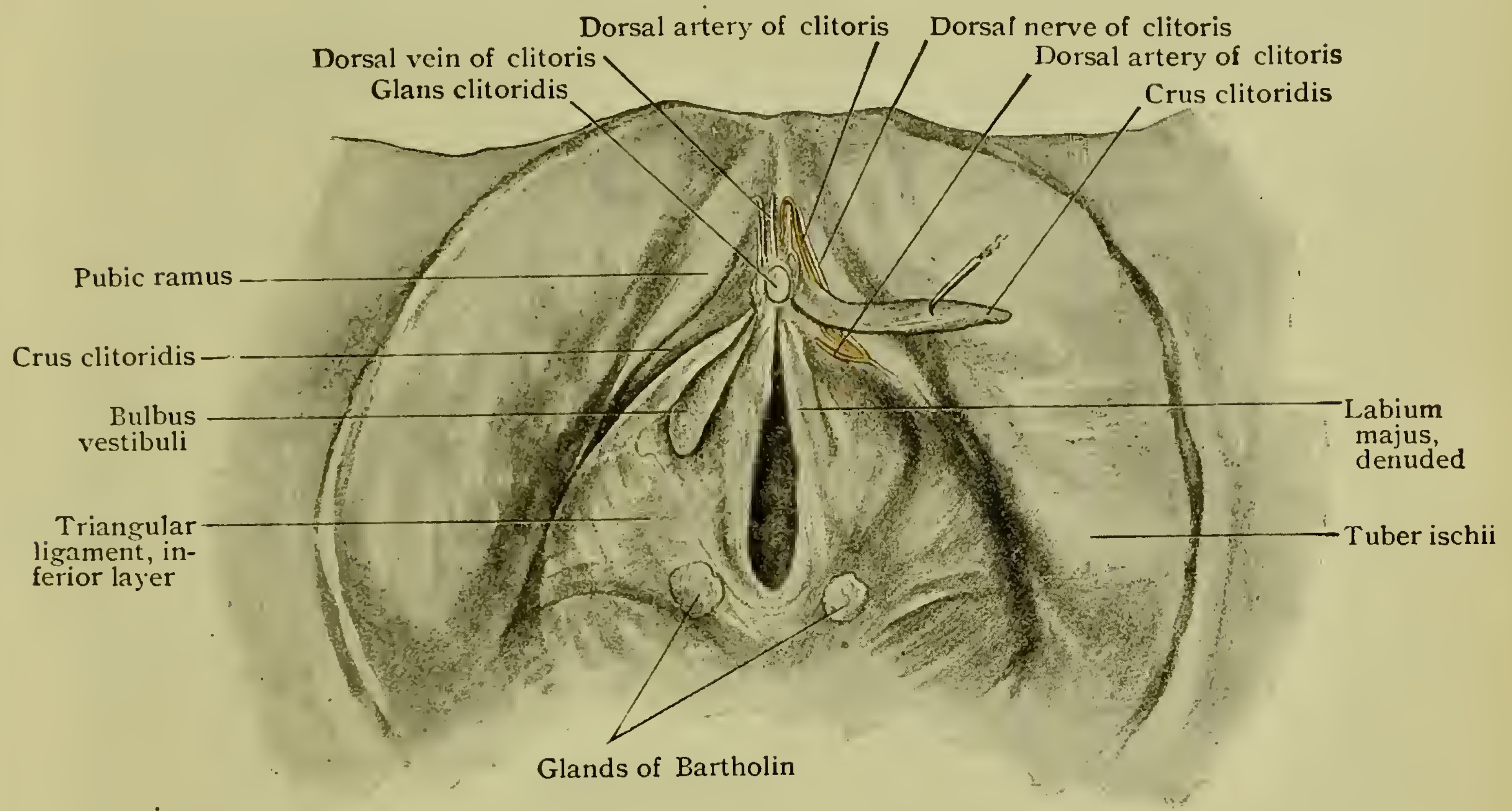

FIG. 276.—Female urogenital triangle showing inferior layer of triangular ligament.

The **gland of Bartholin,** the **vulvo-vaginal gland,** will be found under the back part of the bulb. It therefore occupies a more superficial position than the gland of Cowper, which lies in the deep perineal space.

The glands of Bartholin are frequently infected in gonorrhœa; the *inflammation* may terminate in *vulvar abscess.*

The **floor** of the superficial interspace, the superficial layer of the triangular ligament, is now exposed. After identifying the **dorsal nerve** and **dorsal artery of the clitoris** and the **artery of the corpus cavernosum,** which perforate the ligament in front, the latter may be removed by cutting along its lateral margins, the crura clitoridis (Fig. 276) being removed or detached.

THE DEEP PERINEAL INTERSPACE.—This space is constituted like that of the male (p. 569) except that it does not contain Cowper's glands.

The **internal pudic artery** (p. 570) dividing in front into the *artery of the corpus cavernosum* and the *dorsal artery of the clitoris* (Fig. 277), the **artery of the bulb** and the **dorsal nerve of the clitoris** (p. 570) are to be followed as in the male subject.

The **compressor urethræ** differs from that of the male (p. 569) in that the posterior fibres pass to the vagina.

The **clitoris** differs from the penis only in point of size and in respect to modifications in the corpus spongiosum. The cleft bulb of the latter has been noted (p. 578); another important modification is that the spongy body is not traversed by the urethra as in the male.

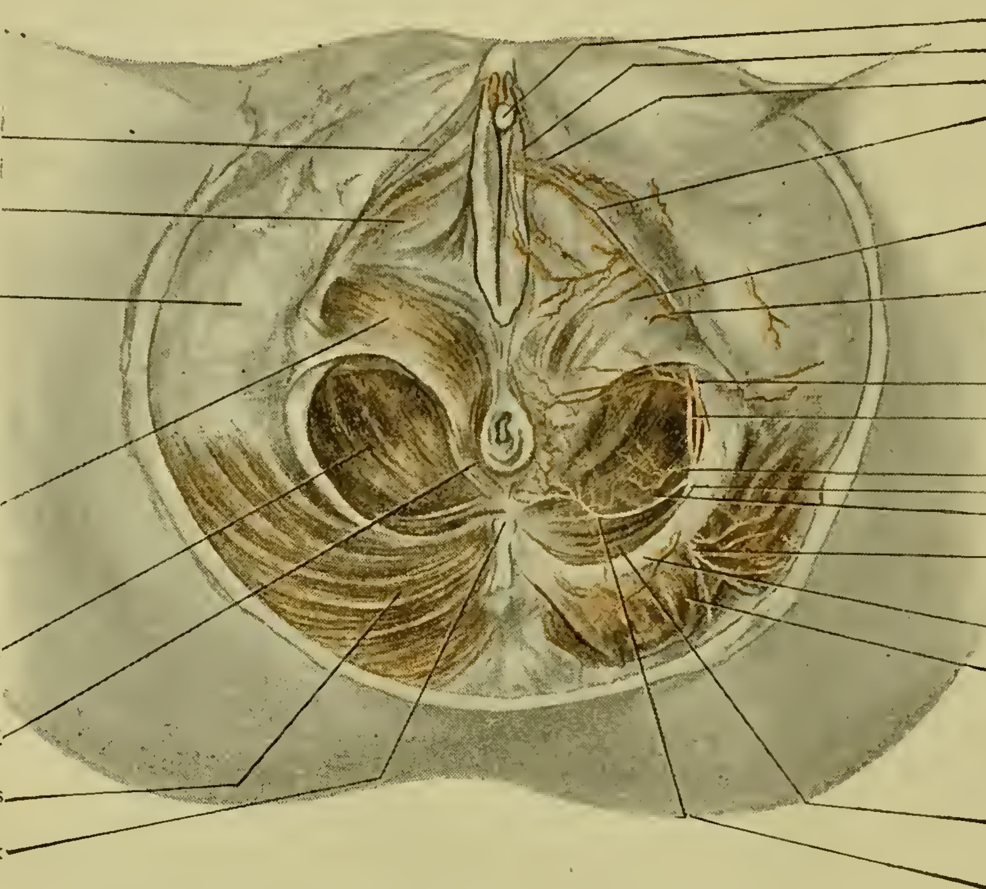

FIG. 277.—Female perineum; deep perineal interspace and ischio-rectal fossæ exposed.

The **dorsal nerve** and **dorsal artery of the clitoris** (Fig. 276) may be followed along the dorsal surface, where the **dorsal vein** will also be found. The course of the latter is like that of the dorsal vein of the penis in the male subject (p. 619).

THE DORSAL SURFACE OF THE TRUNK.

The **surface anatomy** of this region, as well as the **superficial structures,** including the *latissimus dorsi*, the *trapezius* and the *rhomboidei*, are considered with the dissection of the upper limbs (pp. 9–20). Since the dissector of the trunk is properly concerned with the superficial nerves and the lumbar fascia, he may work out these structures jointly with the dissector of the upper limb. He must also work in association with the dissector of the head and neck.

After the muscles named above have been dissected, the trapezius and the rhomboids should be severed from the spines of the thoracic vertebræ and reflected. Such **cutaneous nerves** as have been found should be preserved as guides to the trunks from which they arise by severing their connections with the foregoing muscles and their aponeuroses where the nerves perforate them. For this purpose the apertures may be enlarged with the scalpel, so that the nerves may be left when the muscles are reflected.

Make a vertical incision through the fleshy part of the latissimus dorsi several inches from the outer limit of its aponeurosis, but stopping about two inches short of its lower margin, and reflect it in each direction. In dissecting the inner flap, it will be seen that the aponeurosis blends with an underlying layer of dense fascia, the posterior layer of the lumbar fascia, while under the upper inner portion of the muscle is the flat quadrilateral inferior serrate muscle (Fig. 13).

The **lumbar aponeurosis** (lumbo-dorsal or lumbar fascia) thus exposed is not only the aponeurosis of origin of the latissimus, but is the posterior lamella of the dorsal aponeurosis of the transversalis abdominis muscle (Fig. 278). Traced inward it is seen to be attached to the spinous processes of the lumbar vertebræ, while below it is attached along the crest of the ilium. Covering the large muscular mass of the sacro-spinalis (Fig. 13) it unites at the outer border of the latter (Fig. 278) with a *second layer* which is attached to the tips of the transverse processes of the lumbar vertebræ and thus separates the sacro-spinalis from the quadratus lumborum. This second layer is attached above to the lower border of the last rib and below to the iliac crest. Traced upward, the *superficial* or *posterior layer* of the aponeurosis is continuous with a thinner fascia sometimes distinguished as the *vertebral aponeurosis*, which is attached mesially to the dorsal spinous processes and laterally to the angles of the ribs, its lateral portion below being continuous with the upper border of the posterior inferior serrate muscle. At the upper thoracic region it passes under the posterior superior serrate muscle and farther up under the splenius (Fig. 171) to blend with the deep fascia of the neck. The portion of the deep fascia above the mid-thoracic region is also distinguished as the *nuchal fascia;* the part below this point, as the *lumbo-dorsal fascia.*

Serratus Postícus Inferior (Fig. 13).—**Origin,** aponeurotically from the dorsal lamella of the lumbo-dorsal aponeurosis adjacent to the eleventh and twelfth dorsal and the first and second lumbar spines; **insertion,** the lower borders of the lower four ribs; **nerve-supply,** the ventral divisions of the ninth to twelfth thoracic nerves; **action,** to assist in inspiration by drawing the ribs downward, by which action it counteracts the tendency of the diaphragm to draw the lower ribs upward and inward.

The surface of this muscle having been cleaned, it should be incised near its origin and reflected outward, though, for purposes of comparison, this may be deferred until the upper serrate muscle has been dissected. In its reflection considerable care is necessary to avoid detaching the underlying aponeurosis with it.

Serratus Posticus Superior (Fig. 171).—**Origin,** aponeurotically from the lower part of the nuchal ligament, the spines of the seventh cervical and the first, the second and sometimes the third thoracic vertebræ; **insertion,** the second, third, fourth and fifth ribs, external to their angles; **nerve-supply,** the ventral divisions of the second to the fourth thoracic nerves; **action,** to assist in inspiration by raising the ribs.

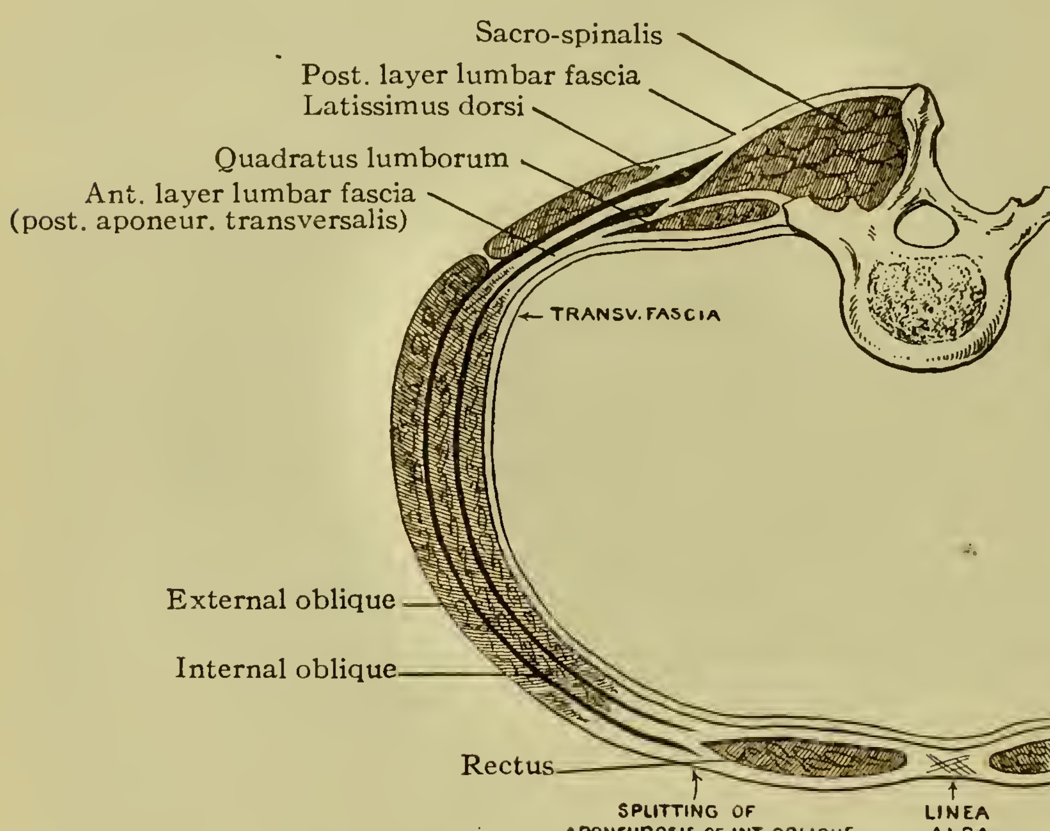

Fig. 278.—Diagram showing lumbar fascia and formation of sheath of rectus abdominis.

After cleaning the surface of the muscle, gently elevate it with the fingers or by blunt dissection and detach it from its origin.

The **splenius** (Fig. 171), now fully exposed, should be dissected (p. 339) and then divided at its origin and reflected.

The attachments of the vertebral aponeurosis should now be noted as well as its thinness and its continuity below with the posterior layer of the lumbar fascia. The former should be removed and the latter reflected outward after having been incised along the vertebral spinous processes. This exposes the deeper muscles of the back and enables the dissector to demonstrate the union of the *posterior lamella of the lumbar fascia* with the *middle layer* (Fig. 278) by displacing inward the outer border of the large muscular mass seen in the lumbar region (Fig. 278).

What is called here the *middle layer* of the lumbar fascia is regarded as the *anterior layer* by those anatomists who do not recognize a third lamella.

The Transverso-Costal Group of Muscles.—The muscles of the back as now seen consist of a large mass, partly tendinous on its surface, in the lumbar and upper sacral regions (Fig. 279), which divides in the lower thoracic or upper lumbar region into three masses, each of which is the beginning of a series of muscles that is continued to the cervical spine and, in the case of the middle series, to the skull. The general direction of the fibres of this group is upward and outward from the transverse processes to the ribs or their representatives; hence they are classified as *transverso-costal.* The **nerve-supply** is the dorsal divisions of the spinal nerves; the **action** in general is extension of the spine.

Sacro-Spinalis or Erector Spinæ (Fig. 279).—This is the large mass referred to above as dividing into three parts. Its **origin** is the spines of the lumbar vertebræ, the posterior surface of the sacrum, the crest of the ilium and the lumbar fascia.

The Ilio-Costalis or Sacro-Lumbalis (Fig. 279).—This is the outer division of the erector spinæ. Separate it from the longissimus on its inner side, noting and preserving the external branches of the dorsal divisions of the spinal nerves that emerge through the interval, and following its subdivisions, the **lumbar portion,** to their insertions upon the six or seven lower ribs. Note the *origin,* from the same ribs of the **dorsal portion,** the **accessorius,** and its *insertion* into the upper five or six ribs, and the *origin* of the last member of the series, the **ilio-costalis cervicis** or **cervicalis ascendens,** from the upper six or seven ribs and its *insertion* into the dorsal tubercles of the fourth, fifth and sixth cervical transverse processes (Fig. 279).

The Longissimus (Fig. 279).—This middle division of the erector spinæ should be noted as constituting a series of muscular bundles extending from the lumbar vertebræ to the mastoid process. Interruptions are seen in the form of attachments to the accessory transverse processes of the lumbar vertebræ, all the thoracic transverse processes, the lower ten or eleven ribs at their angles, the transverse processes of the second to the sixth cervical and the articular processes of the lower three cervical vertebræ. The series thus consists of the **longissimus dorsi, longissimus cervicis** or **transversalis cervicis** and the **longissimus capitis** or **trachelo-mastoid** (p. 341).

The Spinalis (Fig. 279).—The spinalis, the lower part of which, the **spinalis dorsi,** is the innermost division of the erector spinæ, should be identified as a series of bundles which connect the spinous processes with each other from the second lumbar to the last cervical vertebræ and the latter with the occipital bone, uniting with the semispinalis capitis (p. 585) near its insertion. It thus includes the **spinales dorsi,**

cervicis et capitis. It properly belongs to the next group of muscles. The muscles of this group should now be removed on one or both sides, the *nerves* and any *arteries* encountered being preserved for further examination.

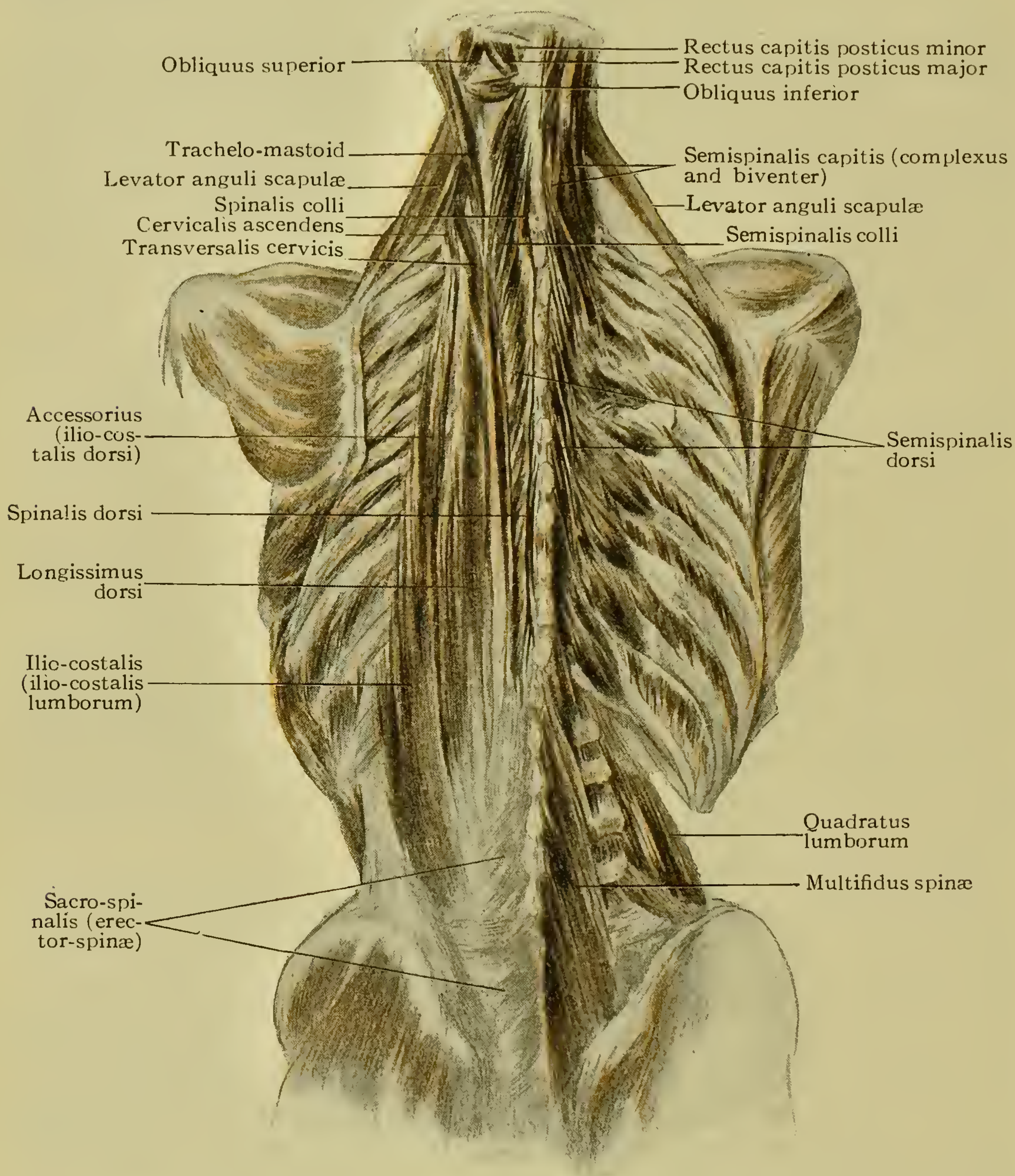

Fig. 279.—Dissection of muscles of back, showing transverso-costal and transverso-spinal tracts.

The Transverso-Spinal Group of Muscles.—The fibres of this group, arising generally from the transverse processes of the vertebræ, pass upward and inward to be inserted into the spinous processes. The **nerve-supply** is from the dorsal divisions of the spinal nerves; the **action**

is extension of the spine and, in the case of those muscles attached to the skull, extension of the head.

The Semispinalis.—Identify the **semispinalis dorsi** (Fig. 279) as connecting the lower six or seven thoracic transverse processes with the upper five or six thoracic and the lower two cervical spinous processes; the **semispinalis cervicis** (Fig. 279) as connecting the five or six upper thoracic transverse processes with the spinous processes of the second, third, fourth and fifth cervical vertebræ. To expose the latter, the last member of the series, the **semispinalis capitis** (complexus and biventer, p. 341) must be removed. This entire group of muscles may now be cleared away to expose the deep short muscles, care still being exercised to preserve the vessels and nerves. The latter are referred to on page 15.

The Multifidus (Fig. 280).—The multifidus should be recognized as a series of short muscles extending from the base of the sacrum to the axis, each member of the series arising from the articular and transverse process of one vertebra and being inserted into the spinous process of the second, the third or the fourth vertebra above. The **action** is rotation and extension of the spine.

The **rotatores** will be found upon removal of the multifidus as small muscles connecting the transverse process of one vertebra to the root of the spinous process next above and to that of the second one above (Fig. 280).

The **intertransversales** (Fig. 280), found only in the cervical and lumbar regions, connect the transverse process of one vertebra with that of the next.

The **interspinales** (Fig. 280) are small fasciculi connecting adjacent spinous processes. They are least marked or absent in the thoracic region.

The **levatores costarum** (Fig. 280) should be examined and noted as *arising* respectively from the transverse processes of the seventh cervical and of all the thoracic vertebræ and as being *inserted* into the rib below between its tubercle and angle.

The **dorsal branches of the aortic intercostal arteries** and those of the **lumbar arteries** will be found between the transverse processes in the thoracic and lumbar regions respectively.

The posterior surface of the **quadratus lumborum muscle** (Fig. 279) may now be examined, a vertical incision being made through the middle layer of the lumbar fascia near the tips of the transverse processes (p. 581). It must be disturbed as little as possible and the fascia should be reunited.

The Dorsal Divisions of the Lower Spinal Nerves.—The **cutaneous branches** of these nerves having been worked out and their **muscular branches** recognized, they are to be traced to their points of exit from the spinal canal.

The **dorsal division of the coccygeal nerve** and **that of the fifth sacral nerve** emerge through the lower end of the sacral canal (Fig. 281) and may be exposed by cautiously working through the aponeurotic tissue found here.

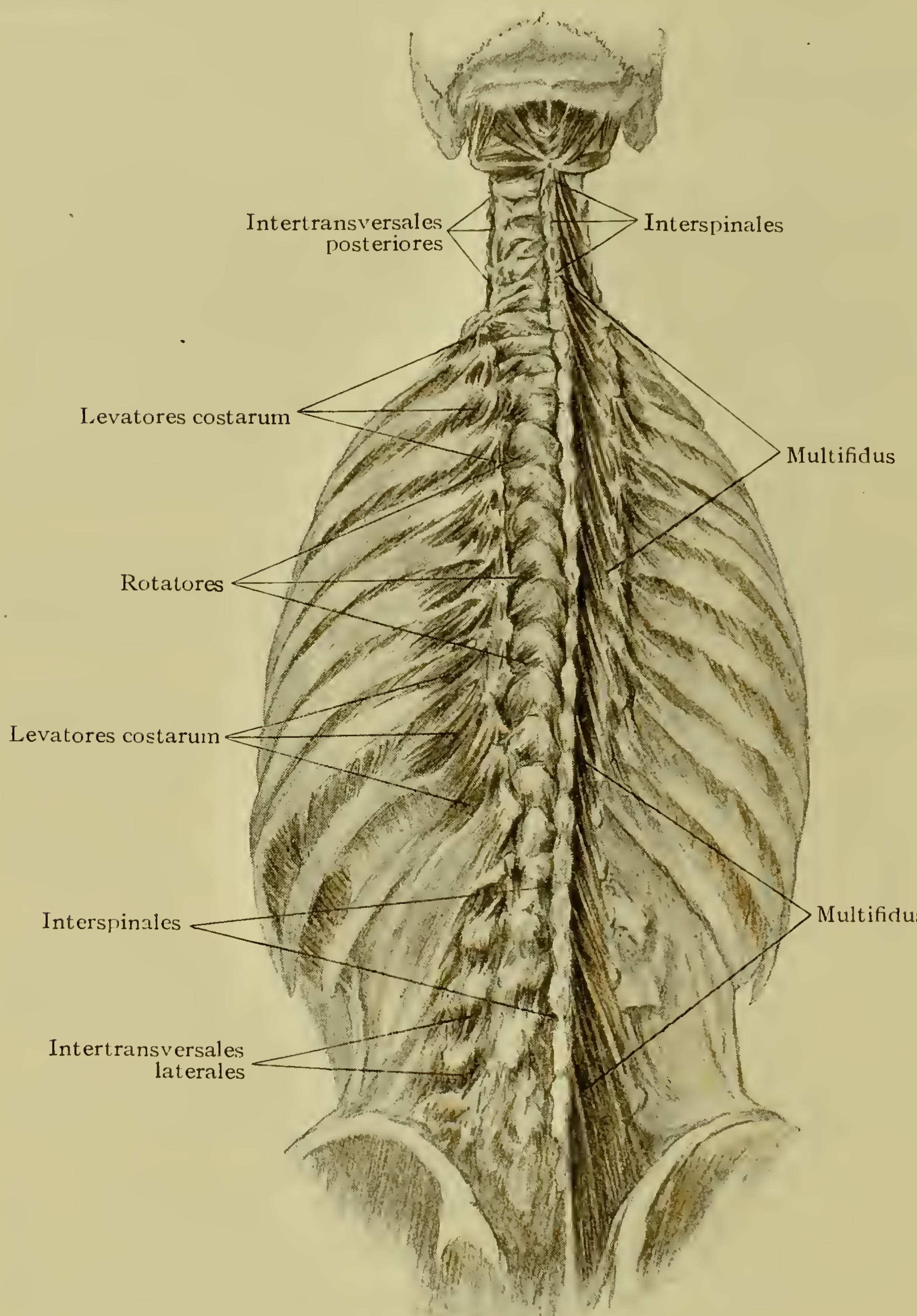

FIG. 280.—Deep muscles of back.

The **first three sacral nerves** will be seen to divide into *external branches*, which inosculate to form the **posterior sacral plexus,** and *internal branches* for the multifidus. The *branches of the plexus* should

be traced to their second series of loops beneath the gluteus maximus, and the *branches* of these to the skin of the buttock (Fig. 281).

The **dorsal divisions of the fourth and fifth sacral and of the coccygeal nerve** do not divide into internal and external branches, but communicate with each other and are distributed to the skin of the coccygeal region.

The joints of the spine are considered at page 489.

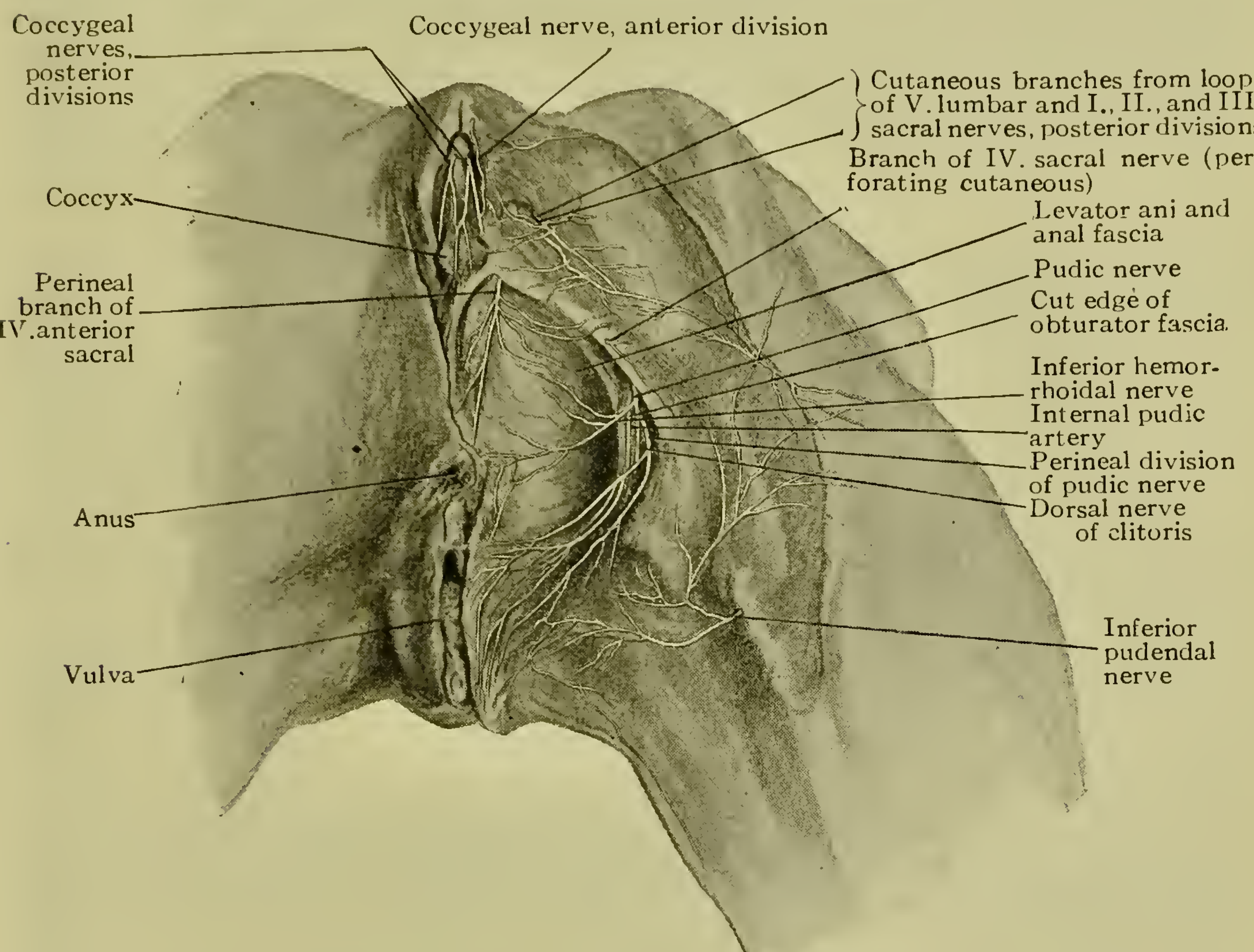

FIG. 281.—Superficial dissection of right side of female perineum and adjacent region, showing cutaneous nerves; obturator fascia has been partly removed to expose pudic nerve and accompanying blood-vessels in canal on outer wall of ischio-rectal fossa.

The **spinal canal** should now be opened. If the dissectors working on other parts of the dorsal surface of the body have completed their work and are ready to have the body reversed, the opening of the canal may be deferred until the abdominal and thoracic cavities shall have been dissected. This plan will offer the additional advantage of enabling the dissectors of the head and of the trunk to collaborate and open the entire length of the canal.

THE SPINAL CANAL.

To expose the spinal cord within the spinal canal the laminæ of the vertebræ must be sawn through, the saw being applied on each side of the line of the spinous processes and close to the articular processes so as to cut the bone about a half-inch from the bases of the spines. Upon removal of the sawn parts the dura mater will be exposed (Fig. 232).

The **dura mater of the spinal cord** differs essentially from that of the brain, first, in not being adherent to the bones of the spinal column, except at a few points, as upon the posterior surfaces of the bodies of the second and third cervical vertebræ and at the various intervertebral foramina where the *dural sheaths* which are prolonged upon the spinal

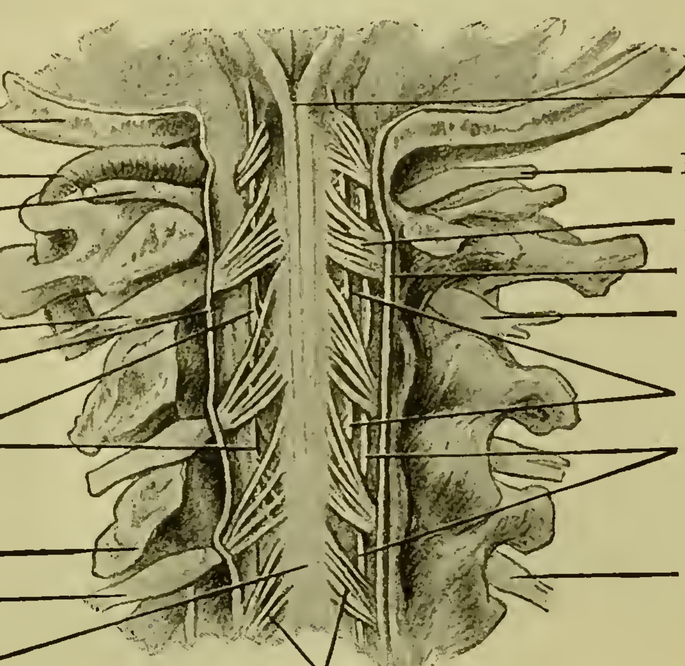

FIG. 282.—Upper end of spinal cord, viewed from behind after partial removal of dural sheath; cord-segments are indicated by groups of converging bundles of posterior root-fibres; spinal ganglia are seen lying within the intervertebral foramina; spinal accessory nerve is seen ascending on each side.

nerves become continuous with the periosteum. The space between the dura mater and the bones is occupied by loose areolar tissue and some venous plexuses and in the sacral part of the canal considerable fat. A second point of difference is that the dura mater of the cord does not separate to form venous channels or sinuses as in the case of the cranial dura; and, third, it does not send processes between any subdivisions of the cord, as in the case of the falx cerebri and tentorium cerebelli.

The dura mater may now be incised along the mid-line posteriorly and the edges of the incision pulled apart and fixed by means of hooks or clips. The **subdural space,** a merely potential space beneath the dura lined with endothelium, will probably not be discovered in this procedure, but the dissector will probably have gone through the outermost layer of the arachnoid and have opened the subarachnoid space, which contains the cerebro-spinal fluid.

The **arachnoid,** the middle membrane of the spinal cord, like that of the brain, is composed of a mesh-work of connective tissue bands enclosing a series of spaces which collectively constitute the **subarachnoid space.** This space is continuous above with the corresponding space of the brain, so that the cerebro-spinal fluid of the cord may pass into the cranial subarachnoid space and *vice versa.*

Spina bifida is a congenital deficiency in the laminæ of the vertebræ which may implicate any portion of the spinal column. When such deficiency exists the membranes of the cord and, in some cases, the cord itself may be forced through the opening, forming a soft, elastic tumor beneath the skin, which becomes tense during expiratory efforts on the part of the patient. *Meningocele* is the name applied to a protrusion simply of the membranes, while *meningomyelocele* is applied to that condition in which the cord and membranes protrude.

The **ventral** and **dorsal roots** (Fig. 12) of the spinal nerves throughout that region of the cord which has been exposed by the incision of the dura, should be sought on either side of the cord. They will be seen to pass outward and downward, the vertebral and dorsal roots of the same side converging toward each other. If a ventral and a dorsal root of the same level be carefully separated, the delicate sheath of arachnoid that invests each will be seen. As the roots pass beyond the periphery of the dura, the dural sheath for each will be noted, these uniting to form a common sheath beyond the **spinal ganglion** (Fig. 282). Exploration of the space between the intradural parts of a ventral and dorsal root will disclose a triangular outward extension of the pia mater, one of the processes of the ligamentum denticulatum referred to below.

The **cauda equina** (Fig. 283), the bundle of strands in the lower part of the spinal canal, should be noted as consisting of those spinal nerves that pass down the canal for some little distance before making their exit from the latter. This arrangement obtains by reason of the fact that the spinal cord terminates at the lower border of the first lumbar vertebra in the adult, in consequence of which the lumbar, sacral and coccygeal nerves must pass downward to their respective foramina to make their exit from the canal, thus making up the cluster of nerve-trunks constituting the cauda equina.

The **conus medullaris,** the conical termination of the cord, should be looked for in the region of the second lumbar vertebra, the nerves of the cauda being separated for this purpose; the **filum terminale,** the slender prolongation of the conus downward through the centre of the cauda, may be traced usually to the lower part of the posterior surface of the sacrum, where it blends with the periosteum. The **coccygeal nerves** will be found one on either side of the filum terminale, passing downward to make their exit from the canal where the latter opens out upon the posterior surface of the sacrum (Fig. 283).

The division of the vertebral laminæ above directed may be made throughout a limited section of the spinal column or, if the spinal cord is to be removed, throughout its entire length. In the latter case the cord and its membranes may now be removed after first cutting the spinal nerves as close as possible to the intervertebral foramina.

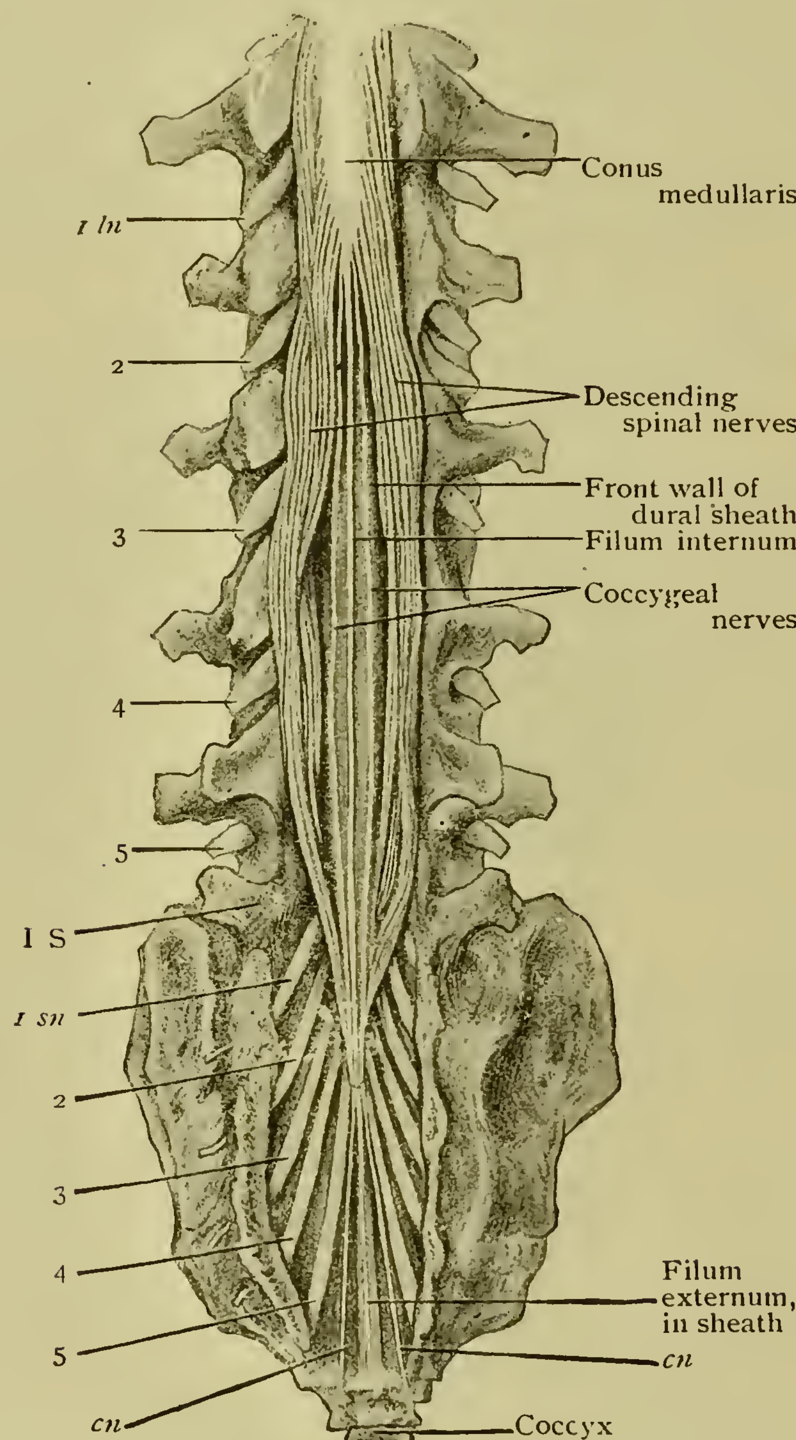

FIG. 283.—End of spinal cord with roots of lower nerves descending in cauda equina to gain their respective foramina; 1-5 *ln*, 1-5 *sn*, *cn*, lumbar, sacral and coccygeal nerves.

After the removal of the cord from the canal, the anterior wall of the dural sheath may be incised in the mid-line throughout the length of the cord so as to bring into view the anterior surface of the pia mater with its longitudinal marking, the **linea splendens** and the anterior spinal artery.

The **pia mater,** the innermost membrane of the spinal cord, which supports the blood-vessels of the latter, closely invests it and sends fibrous processes from its deep surface into the interior of the cord to assist in forming its stroma (Fig. 232).

Between each ventral and dorsal root will be found a projection from the pia mater which is connected by its apex with the dura mater, the series of projections on either side constituting the **ligamentum denticulatum** of the pia.

The **arteries of the spinal canal and of the cord** include certain branches of the vertebral artery (p. 489), and the spinal branches of the aortic intercostals in the thoracic region, of the lumbar arteries in the lumbar region and of the lateral sacrals in the sacral region. **Each vessel,** upon entering the spinal canal through an intervertebral foramen, sends a *branch to the dorsal wall of the canal*, a *branch to the ventral wall* and a *branch to the spinal cord*. The **branch to the ventral wall** divides into an *ascending* and a *descending ramus*, these uniting with their neighbors next above and below to form a series of arches which lies upon the posterior surfaces of the vertebral bodies and which is continued throughout the length of the spinal canal. The series of the two sides communicate with the *anterior spinal branch* from the cranial portion of the vertebral (p. 498) which lies within the dural sheath and extends throughout the length of the cord along the line of its anterior median fissure.

The study of the central nervous system may properly begin with the study of the structure of the spinal cord. While the student is referred to the text-books of descriptive anatomy for a detailed account of this structure, it is essential to a proper understanding of the dissection of the cerebro-spinal axis to take note of the salient features of the constitution of the spinal cord as a preliminary to the dissection of the brain. After the hardening of the cord in formalin (p. 332) the student may make a few transverse sections as, for example, through the *cervical* and *lumbar enlargements*, to be examined by the aid of a pocket lens. In this way a general idea may be obtained of the arrangement of its elements.

The **central gray matter** of the spinal cord, made up of nerve-cells supported by neuroglia and connective tissue stroma, presents the enlargements known respectively as the **anterior** and **posterior gray horns,** and, in certain regions, as in the *cervical enlargement*, also the **lateral gray horn.** The **anterior horns** contain large pyramidal cells arranged in several groups, the axones of which pass out of the cord as the ventral or motor nerve-roots of the spinal nerves to terminate in the muscles of the body. The cells of the **lateral horn,** which, though present as a distinct lateral projection only in certain regions, is represented practically throughout the entire length of the cord as the *intermedio-lateral group*

of cells, send their axones forward to emerge with the ventral nerve-roots and to proceed to the unstriped muscular tissue of blood-vessels and of certain organs as well as to secretory structures. The **posterior gray horns** contain various groups of cells, mostly of small size, some of whose axones pass up the cord on the opposite side, forming afferent fibre-tracts. The cells of the posterior horn receive the arborizations of some of the fibres of the posterior roots of the spinal nerves. The cells of **Clarke's column,** at the base of the posterior cornu, send their

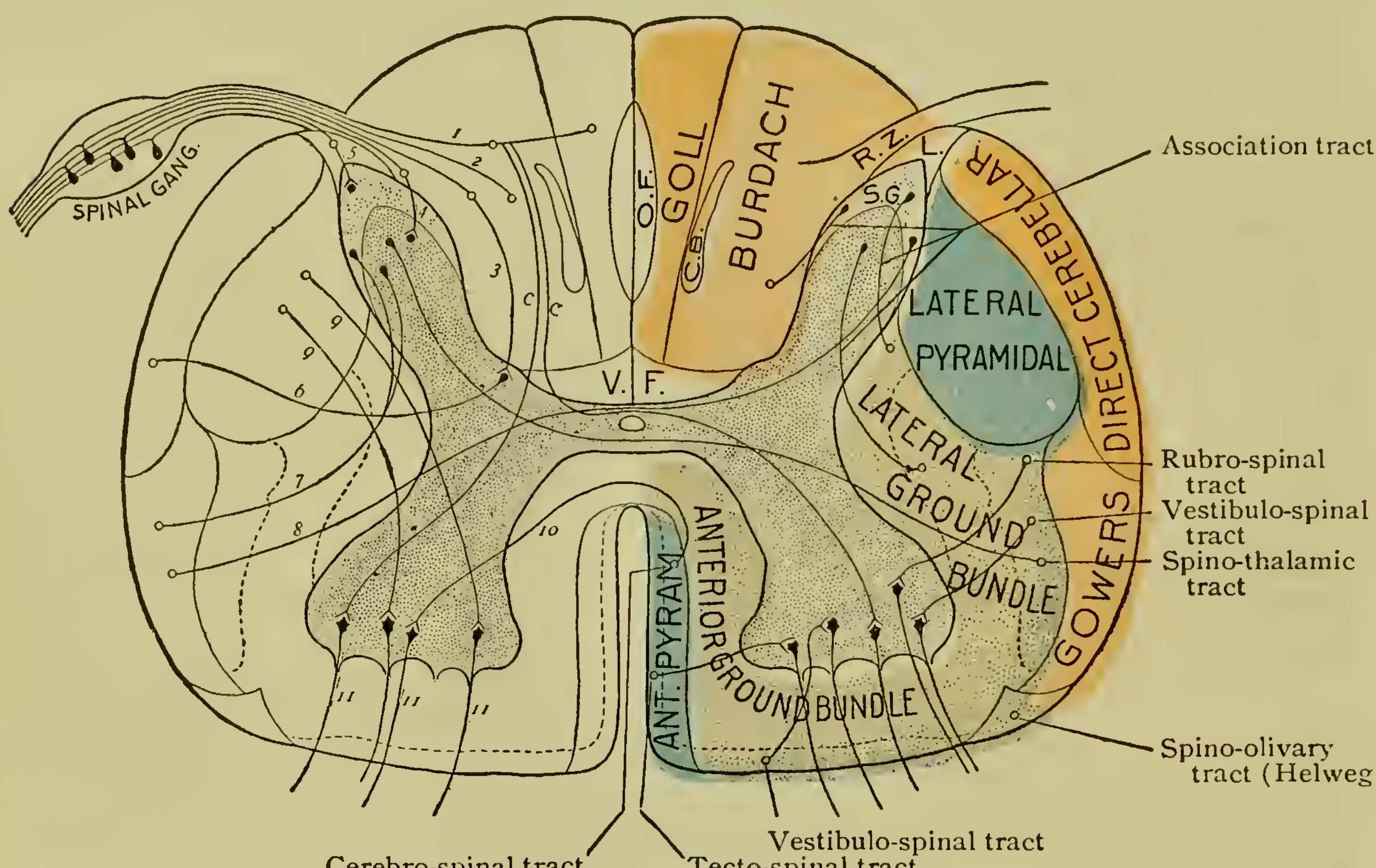

FIG. 284.—Diagram of spinal cord, showing position of chief tracts and relations of their component fibres to nerve-cells; 1–5, posterior root-fibres entering root-zone (R.Z.) and Lissauer's tract (L.), open circles (o) indicate that fibres pass up and down; *c*, *c*, collaterals from long ascending tracts (1, 2) to anterior root-cells; 3, fibres ending around cells of Clarke's column; 6, fibres forming direct cerebellar tract; 7, 8, fibres forming Gowers' tract; 9, 10, fibres from lateral and direct pyramidal tracts; 11, 11, anterior root-fibres; V. F., ventral field; O. F., oval field; C. B., comma bundle.

axones to the lateral portion of the cord, where they turn upward to constitute an important afferent tract, the direct cerebellar.

The peripheral **white matter** of the spinal cord, made up of nerve-fibres, is divisible into various *afferent* and *efferent tracts.*

The most important **efferent tracts** are the *direct pyramidal,* situated near the ventro-mesial fissure, and the *crossed pyramidal* in the lateral portion of the cord upon the inner side of the direct cerebellar tract.

The **direct pyramidal tract** or **column of Türck** is made up of the axones of cells situated in the motor area of the cortex of the cerebrum; continuing down the spinal cord on the same side upon which they start,

they terminate at various levels by passing through the anterior white commissure to the opposite anterior gray horns around the cells of which they arborize.

The **crossed** or **lateral pyramidal tract,** made up of the axones of cells of the motor area of the cortex, cross to the opposite side in the lower part of the medulla oblongata, thus pursuing a course through the spinal cord on the side opposite their origin. These axones terminate at various levels by arborizing around the cells of the anterior gray horns. Thus, a motor impulse starting from the cortex is conveyed by the fibres of one of these two tracts to the cells of the anterior gray horn to which it is transferred and by which it is sent to the periphery of the body through the axones of the latter cells.

The chief **afferent tracts** of the cord are the *tract of Goll*, the *tract of Burdach*, the *direct cerebellar tract* and the *tract of Gower.*

The **tract of Goll,** situated next the posterior median septum, is made up of long fibres which are the axones of the cells of the posterior root ganglia. This tract is traceable into the medulla as the fasciculus gracilis of the latter, the fibres terminating in the nucleus gracilis or nucleus of Goll by arborizing about its cells.

The **tract of Burdach,** situated between the tract of Goll and the posterior gray horn, is not distinguishable as a separate tract below the mid-dorsal region, the successive entrance of the fibres constituting it from the latter point upward crowding the tract of Goll toward the mesial plane. This tract is made up partly of *long fibres*, the axones of cells of the spinal ganglia, as in the case of the fibres of Goll's tract; they pass into the medulla as the fasciculus cuneatus to terminate by arborizing around the cells of the nucleus cuneatus (Burdach's nucleus). Aside from the long fibres, the tract of Burdach includes short fibres, some of which connect different levels of the gray matter of the posterior horn; other short fibres coming from the posterior root ganglia divide upon entering the cord into an *ascending* and a *descending branch*, the latter branches being found at different levels as small tracts of descending fibres within the tract of Burdach under the various names of the *comma tract* at the level of the ninth to tenth dorsal segments; the *septo-marginal tract*, the *triangular median tract*, and the *oval field* at successively lower levels. The bulk of the tract of Burdach is still further augmented by the passage through it of fibres from the posterior root ganglia on their way to their destinations, as for example those fibres which pass from the posterior roots to terminate by arborizing around the cells of Clarke's column.

The tracts of Goll and Burdach convey impressions of muscular sense and, to a less extent, of tactile sense, and thus, in *locomotor ataxia*, these impulses being interfered with by the sclerosis of these tracts, the equilibration of the body is interfered with and incoördination of locomotion results.

The **direct cerebellar tract,** situated at the peripheral part of the lateral column of the cord in front of the posterior horn, consists of the axones of the cells of the column of Clarke. Traced upward, this tract enters the medulla and constitutes a large part of the restiform body or inferior peduncle of the cerebellum, which is continued into the latter portion of the brain. Since the cells of the column of Clarke receive the arborizations of axones from the cells of the spinal ganglia, it is evident that an impulse of tactile or of muscular sense traversing the direct cerebellar tract has originated in the periphery of the body and has reached this tract by way of Clarke's column.

The **tract of Gower,** situated in the lateral portion of the cord in front of the direct cerebellar, consists of axones of cells of the posterior gray horn of probably the opposite side. After entering the medulla it assumes new relationships, part of its fibres proceeding to the cerebellum by way of the superior peduncles of the cerebellum.

That portion of the white matter of the spinal cord lying between the bases of the horns of one side, the *lateral ground-bundle*, and that portion lying internal to the anterior horn, the *anterior ground-bundle*, collectively constitute the *mixed antero-lateral tract.* This region, besides containing *intersegmental association fibres* for the adjacent anterior gray horns and containing fibres on their way from the crossed pyramidal tract to the anterior horns, contains a number of small tracts not sharply defined from each other, such as the *spino-thalamic* and the *spino-olivary*, and such efferent tracts as the *rubro-spinal*, the *vestibulo-spinal* and the *olivo-spinal tracts.*

The **tract of Lissauer** is a small column situated in relation with the apex of the posterior gray horn and is made up of fibres from the posterior roots, axones of cells of the spinal ganglia, which pursue a short course upward or downward before entering the gray matter of the horn, there to terminate by arborizing about its cells.

The Dorsal and Ventral Roots of the Spinal Nerves.—Each spinal nerve is connected with the spinal cord by two bundles of fibres, respectively the *anterior* or *motor root*, and the *posterior* or *sensory root.* The union of these two constitutes the spinal nerve in question.

The **ventral roots** are made up of the axones of cells of the ventral and of the lateral horn or, at levels where the latter is absent, of its representative, the intermedio-lateral tract.

Upon the **posterior root** is found the **spinal ganglion,** each cell of which gives forth an axone which divides into a fibre passing peripherally as a peripheral sensory nerve-fibre, and a fibre which passes into the spinal cord as a posterior root-fibre.

The **fibres of the posterior roots** take various courses after penetrating the spinal cord: some fibres, first forming the tract of Lissauer, enter the apex of the posterior horn to arborize about its cells; other

fibres pass toward the posterior median septum and turn upward, forming the tract of Goll; other fibres turn upward in the posterior column to form the tract of Burdach; other fibres, entering the tract of Burdach, divide into an ascending and a descending branch; from these, *short collateral branches* arise which terminate by arborizing about the cells of the posterior gray horn, while *long collaterals* pass forward to terminate by arborizing around the cells of the anterior gray horn, thus completing the link of a simple spinal reflex; other fibres pass through the tract of Burdach to terminate by arborizing around the cells of Clarke's column.

THE ANTERIOR ABDOMINAL WALL.

THE SURFACE ANATOMY.

With the subject lying upon its back (Fig. 286), blocks under the shoulders and the lower part of the thorax and the anterior abdominal wall rendered more prominent, if necessary, by a moderate degree of inflation of the abdominal cavity by the introduction of a blow-pipe through the navel, the surface markings of the abdominal wall should be studied. This area is limited above by the **costal angle,** at the apex of which is the **ensiform cartilage** of the sternum; from this point diverge the **costal margins,** constituted by the cartilages of the ribs from the sixth to the tenth inclusive. These features are plainly obvious to both sight and touch. At the lower limit of the wall, at the median line, is the **symphysis pubis,** from which passes out on either side the **crest of the pubis,** terminating in a small tubercle, the **pubic spine.** The spine of the pubis is easily recognizable in a thin subject, but may be quite obscure in the obese. It may be located and identified by following up the tendon of the adductor longus, made tense by abducting the thigh, or by invaginating the scrotum with one finger and following the spermatic cord upward to the pubic spine. The **crests** of the ilia are easily recognized along the lateral aspect of the lower part of the abdomen and may be followed to their anterior terminations, the **anterior superior spines.** A furrow, the **fold of the groin,** leading from the anterior superior iliac spine to the pubic spine, indicates the position of Poupart's ligament. The **linea alba** (Fig. 285) is a surface marking extending from the ensiform to the pubic symphysis, near the centre of which is the **umbilicus.** The linea alba, marked above the umbilicus by a furrow, indicates the line of continuity between the abdominal aponeuroses of the two sides. The **linea semilunaris** is a surface marking extending from the ninth costal cartilage downward and arching slightly inward to the spine of the pubis. It indicates the outer border of the rectus abdominis muscle. The **lineæ transversæ** are transverse markings extending between the linea semilunaris and the linea alba and are usually three in number, one at or near the level of the umbilicus, one near the ensiform

cartilage, and one mid-way between these two. They are produced by tendinous intersections in the rectus muscle. The skin of the anterior abdominal wall is of rather delicate texture and in some cases the course of the superficial veins may be easily recognized by sight. This is especially true when the veins are enlarged, as they sometimes are when the venous circulation of the alimentary canal—the portal system—is obstructed.

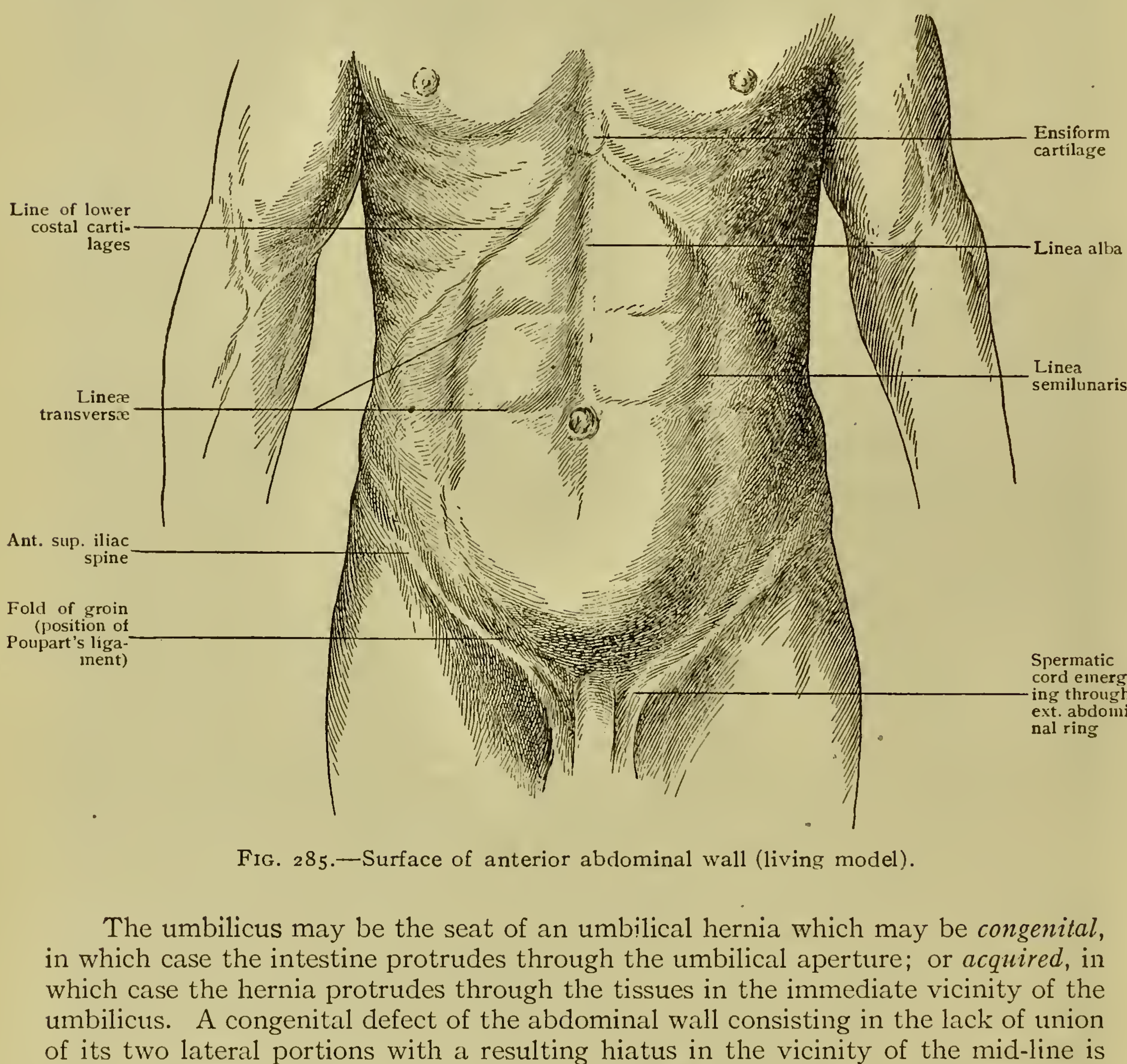

FIG. 285.—Surface of anterior abdominal wall (living model).

The umbilicus may be the seat of an umbilical hernia which may be *congenital*, in which case the intestine protrudes through the umbilical aperture; or *acquired*, in which case the hernia protrudes through the tissues in the immediate vicinity of the umbilicus. A congenital defect of the abdominal wall consisting in the lack of union of its two lateral portions with a resulting hiatus in the vicinity of the mid-line is seen as a part of the abnormality known as *exstrophy of the bladder*, in which condition the anterior wall of the bladder is also deficient.

DISSECTION.

A median incision should be made from the ensiform to the symphysis pubis, and a transverse incision from the ensiform outward to the mid-axillary line (Fig. 286). A third incision may be made along the line of Poupart's ligament. Beginning at either the upper or the lower

corner of the flap thus outlined, the skin should be reflected toward the lateral region of the abdomen, the dissector taking care to leave the superficial fascia.

The Superficial Fascia.—The superficial fascia here, as in other situations, is more or less rich in fat, the deposit of fat in obese subjects attaining to the thickness of three quarters of an inch or more. Upon the lower part of the abdominal wall the superficial fascia is divisible into a superficial and a deep layer. The **superficial layer,** the **fascia of Camper,** containing the fat of the superficial fascia, is directly continuous with the similar layer of the front of the thigh, with the superficial fascia of the thorax and with the superficial layer of the dartos of the scrotum and penis; ramifying partly within the superficial layer and partly between it and the deep layer are the *superficial vessels and nerves.*

Fig. 286.—Cadaver showing lines of incision.

The **veins** not infrequently are visible, at least in part, and serve as guides to the arteries, which lie deeper. A rather large venous trunk on the lateral part of the abdominal wall, the *thoraco-epigastric vein* (Fig. 287), opens into the long thoracic vein near its termination in the axillary vein; it communicates below with tributaries of the femoral vein. It should be noted that the superficial veins of the abdominal wall drain upward into the axillary vein, and, below the level of the umbilicus, downward into the femoral vein.

A small flap of the superficial layer should be reflected by making a transverse incision from a point about two inches below the umbilicus, supplementing this with a median incision down to the symphysis pubis. The upper, inner angle of this flap should be raised cautiously so as not to take up with it the deep layer, and should be reflected downward

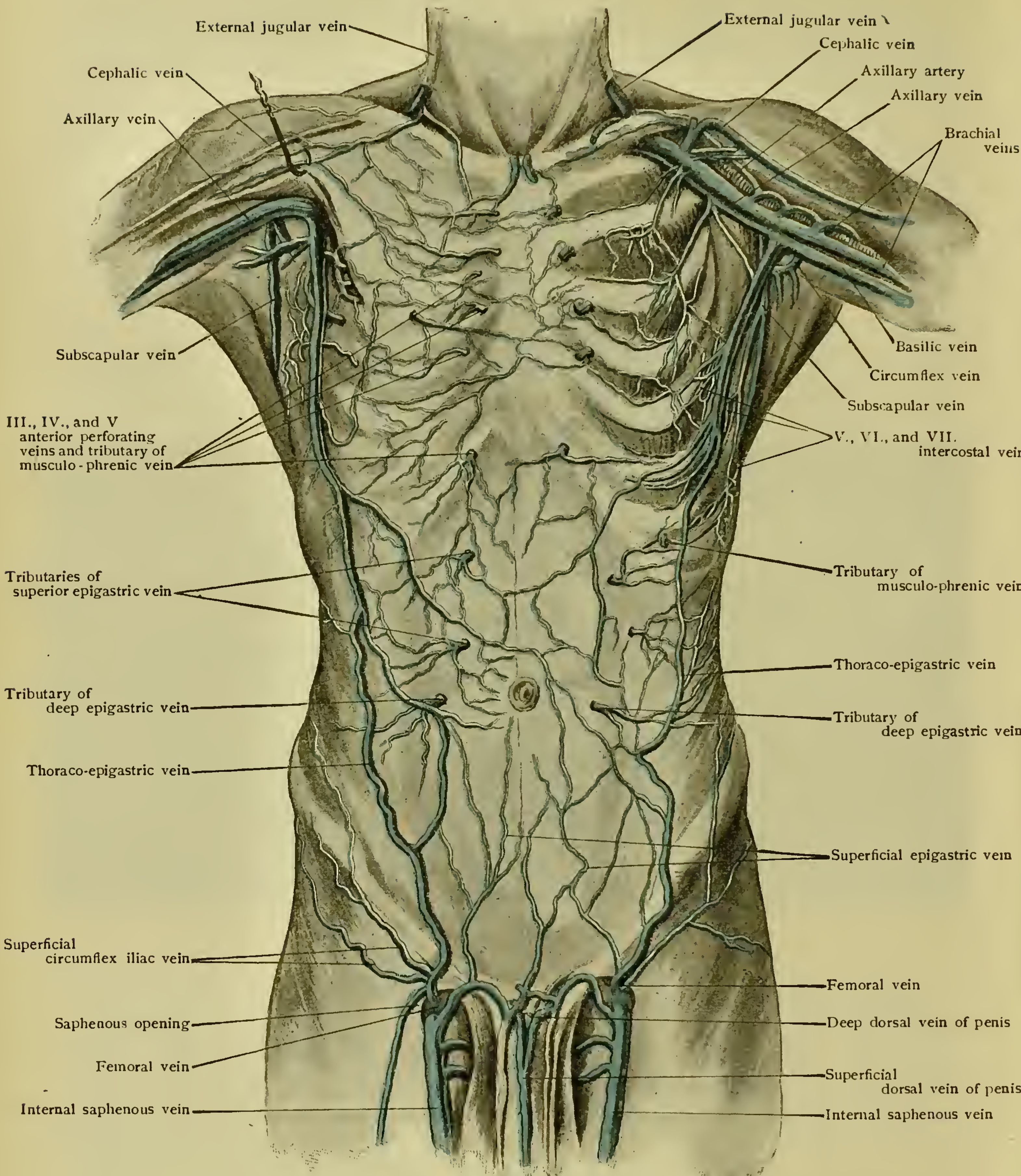

FIG. 287.—Superficial veins of anterior body-wall; pectoralis and external intercostal muscles (of fifth to seventh intercostal spaces) on left side have been removed.

and outward, the presence of the superficial vessels serving in a measure as a guide to the distinction between the two layers of the fascia. Near the mid-line, small nerves will be encountered as the fascia is raised. As the dissector approaches the pubic region, he will note a marked

thickening of the superficial fascia to form the **suspensory ligament of the penis** (Fig. 100). At the line of Poupart's ligament, he will note that the superficial layer is not bound down along this line but continues without interruption into the thigh.

The Superficial Arteries.—The **superficial epigastric artery** (from the common femoral) passes upward and inward from approximately the middle of Poupart's ligament, accompanied by the superficial epigastric vein (Fig. 98). Upon the lower and inner part of the abdominal wall, the **superficial external pudic artery** (from the common femoral) will be encountered. Other superficial arteries are, in the upper part of the dissection, branches of the intercostal arteries and, in the lower portion, superficial branches of the lumbar arteries.

The Cutaneous Nerves (Fig. 288).—The **hypogastric branch of the ilio-hypogastric nerve** pierces the aponeurosis of the external oblique just above and to the inner side of the external abdominal ring. The **terminal branches** of the lower **seven intercostal nerves** become superficial by piercing the sheath of the rectus about one inch from the midline (Fig. 288). On the lateral region of the abdominal wall, the **lateral cutaneous branches** will be found, usually one for each of the seven lower intercostal nerves. These nerves, with the exception of the hypogastric branch of the ilio-hypogastric, will not be encountered until the entire layer of superficial fascia is dissected, but are mentioned here as a matter of convenience.

The **deep layer of the superficial fascia,** the **fascia of Scarpa,** should now be taken up. As this layer is almost free from fat, its recognition is comparatively easy. In quadrupeds, the fascia of Scarpa is of importance as aiding in the support of the weight of the abdomen and is known as the *abdominal belt.* The dissector must avoid taking with this fascia parts of the underlying external oblique aponeurosis. He will find, at the pubic region, that this fascia is continuous with the deep layer of the dartos of the scrotum and penis, and as he approaches the region of Poupart's ligament he should be able to demonstrate that it passes over this ligament and then becomes rather firmly attached to the deep fascia of the thigh in a line parallel with the ligament and about one half inch below it (Fig. 99). It is not bound down, however, in the region between the spine of the pubis and the symphysis pubis and so continues uninterruptedly over the spermatic cord. It should be followed for some little distance into the scrotum and penis, where it is extremely thin.

This arrangement of the fascia of Scarpa influences the course of *extravasations of blood or serum.* An extravasation of fluid, for example, beneath the dartos from a rupture of the urethra in the superficial perineal interspace, will make its way along the spermatic cord to the abdominal wall and will be prevented from passing to the surface of the thigh by reason of the attachment of this fascia to the deep fascia of the thigh as noted above.

The superficial fascia may now be entirely removed, the dissector not failing to search for and identify the nerves mentioned above. In order to find the nerves, especially the lateral cutaneous branches, it will be necessary to identify them and isolate them in part, if not wholly,

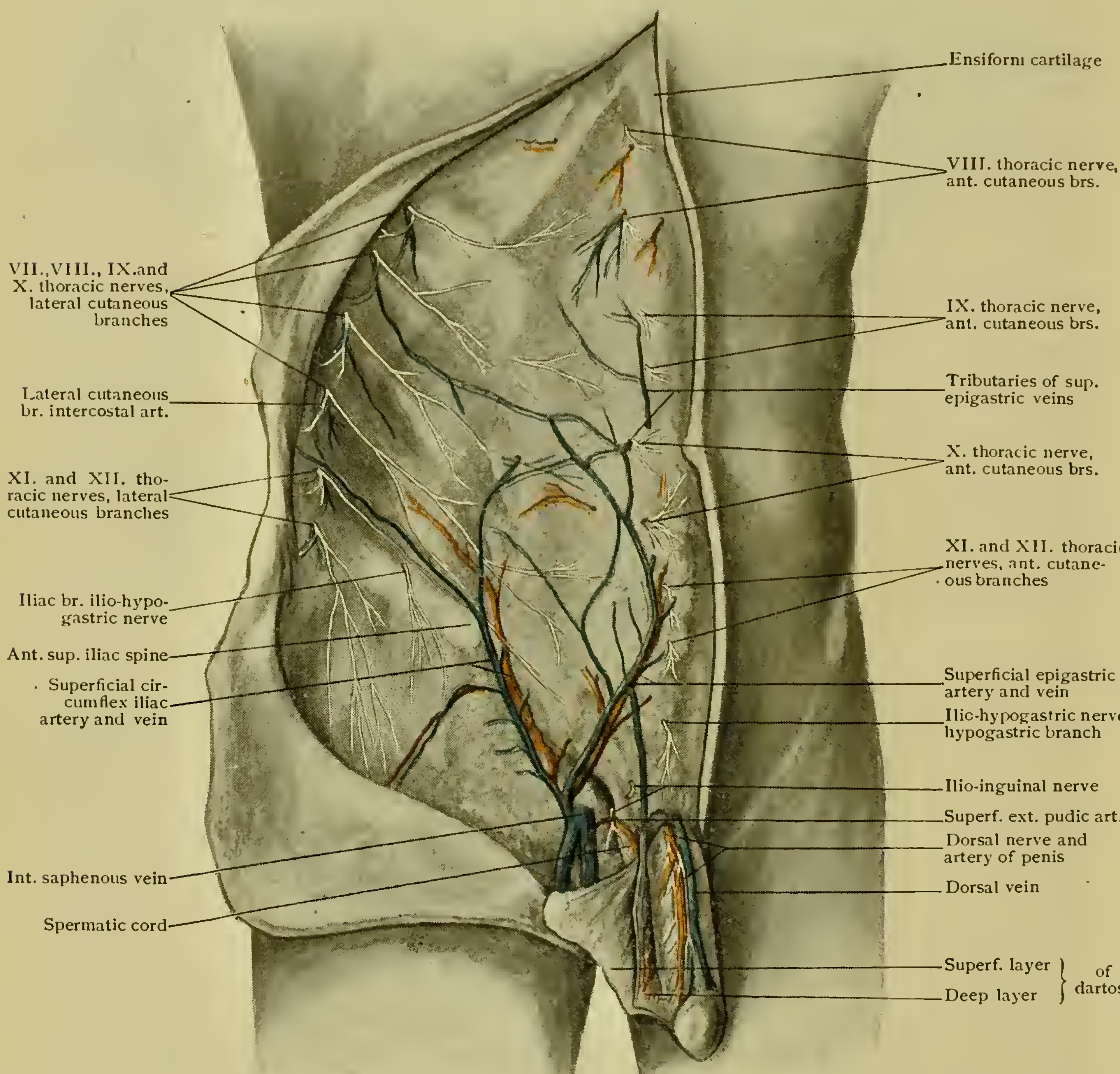

FIG. 288.—Dissection of superficial vessels and nerves of anterior abdominal wall.

before removing the superficial fascia. They may usually be found emerging between the ribs in a line from the middle of the axillary space to a point about two inches behind the anterior superior iliac spine. The nerves at first lie beneath the deep fascia and then upon it, and still later perforate the superficial fascia.

Each **lateral cutaneous branch** divides into an *anterior* and a *posterior trunk* (Fig. 288).

The external oblique muscle and its aponeurosis, covered by a thin layer of deep fascia, are now exposed.

OBLIQUUS EXTERNUS ABDOMINIS (Fig. 289). — **Origin,** the eight lower ribs by eight muscular digitations, of which the upper five interdigitate with the serratus magnus, the lower three with the latissimus dorsi; **insertion,** the anterior third of the crest of the ilium (the posterior fibres), the anterior superior spine of the ilium and the spine and crest of the pubis for the aponeurosis, the latter also interlacing at the linea alba with the aponeurosis of the muscle of the opposite side. **Nerve-supply,** the eighth to the twelfth thoracic and the ilio-inguinal and ilio-hypogastric nerves. **Action,** to assist expiration, defecation, micturition and parturition by compressing the abdominal contents; to assist in anterior and in lateral flexion as well as in torsion of the trunk.

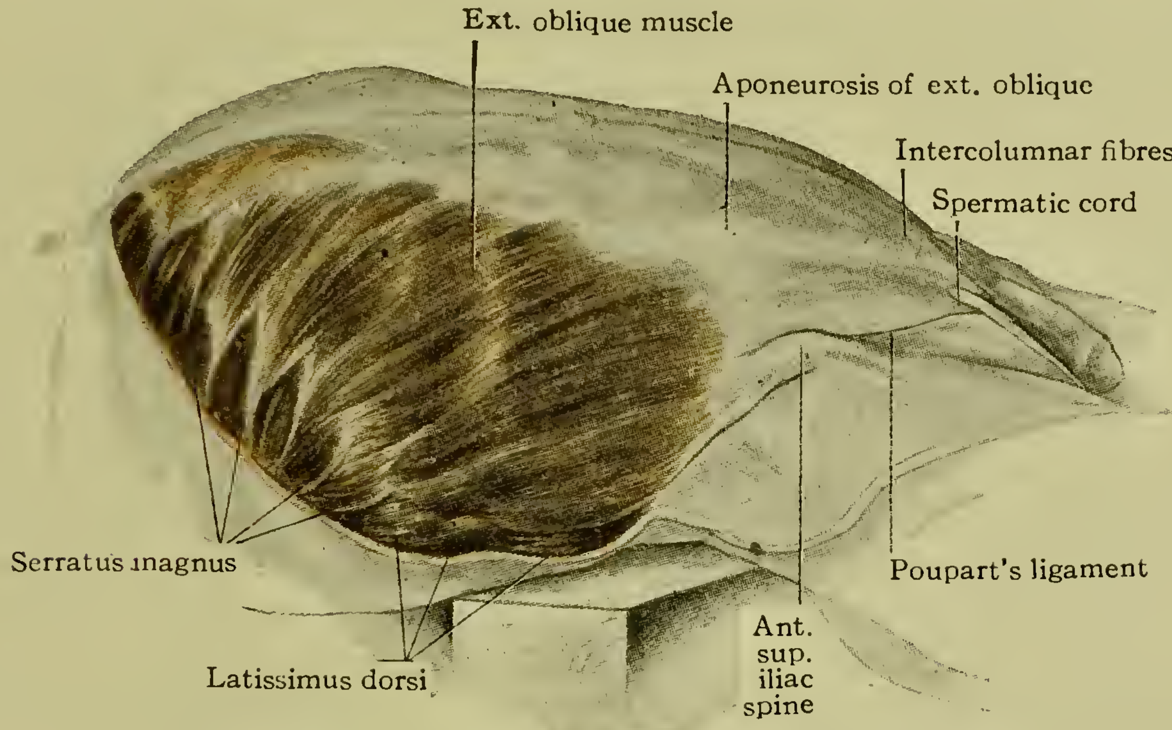

FIG. 289.—Dissection of obliquus externus abdominis.

The thin layer of deep fascia that invests this muscle should be removed—a tedious process—in the direction of the fibres, the surface being moistened from time to time to facilitate the work. The digitations are defined from those of the latissimus and the serratus by yellowish-white lines of connective tissue and may be well exhibited by elevating, but not completely detaching them, from the ribs. The iliac branch of the ilio-hypogastric nerve and, in front of it, the lateral cutaneous branch of the last thoracic nerve (Fig. 288) perforate the muscle near the crest of the ilium to reach the gluteal region. The posterior border of the external oblique diverges from the anterior border of the latissimus as it approaches the crest of the ilium, forming the anterior boundary of a triangular space, the **triangle of Petit** (trigonum lumbale), which is bounded behind by the latissimus and below by the iliac

crest. Its floor is the internal oblique muscle. Having denuded the muscle, its aponeurosis must be freed from any remnants of the superficial and deep fasciæ, when the *linea alba*, the *lineæ transversæ* and the *lineæ semilunares* will appear conspicuously (p. 595).

Poupart's ligament, the ligament of Fallopius (lig. inguinale), that part of the aponeurosis stretching from the anterior superior iliac spine to the pubic spine, is to be noted as a thickened band; it is bound down to the fascia lata of the thigh and is intimately connected with the fascia transveralis along the latter's line of fusion with the iliac fascia.

The **external abdominal ring** (annulus abdominalis subcutaneus) is seen (Fig. 99) as a triangular aperture in the aponeurosis just above the spine and crest of the pubis. Its inner and outer margins, slightly thickened, constitute respectively the **inner** and **outer pillars** (crura) of the ring, the former being attached to the pubic crest and the latter to the pubic spine. The spermatic cord, in the male, or the round ligament of the uterus in the female, is to be seen emerging through the ring. The delicate striations arching between the inner and outer pillars of the ring on the surface of the aponeurosis, are the **intercolumnar fibres.** The delicate **intercolumnar fascia** (external spermatic fascia) is prolonged from the margins of the ring as an attenuated extension of the aponeurosis, to form one of the coverings of the spermatic cord and testicle. The aponeurosis is therefore not actually perforated to permit of the passage of the cord, but is merely prolonged in attenuated form in advance of the descent of the testis. The intercolumnar fascia may be demonstrated by making a small incision through the aponeurosis parallel with and a half-inch above Poupart's ligament, beginning a half-inch to the outer side of the outer margin of the ring that the external pillar may be left intact, and injecting a small quantity of water beneath the aponeurosis, toward the ring, or by gently insinuating the finger or a blunt instrument through the ring from within. By either method, the intercolumnar fascia will be distended (Fig. 99).

The small incision already made through the aponeurosis should now be extended outwardly, parallel with Poupart's ligament, to a point near the anterior superior spine of the ilium and then continued, parallel with the iliac crest and about one inch from it, to the posterior border of the muscle. This incision should include nothing but the external oblique and its aponeurosis; if it be made carelessly, the underlying internal oblique may be taken up prematurely, or the ilio-inguinal nerve, passing inward some little distance above Poupart's ligament, the hypogastric branch of the ilio-hypogastric nerve farther up, or the lateral cutaneous branch of the twelfth thoracic and the iliac branch of the ilio-hypogastric nerve near the crest of the ilium, may be sacrificed.

Gimbernat's ligament (lig. lacunare) (Fig. 294) may now be demonstrated as a triangular sheet presenting a free outer border, the base of

the triangle, an anterior or superior margin continuous with the inner part of Poupart's ligament, and a posterior or inferior border attached to the ilio-pectineal line, the apex of the triangle corresponding with the pubic spine. The concave outer margin may be detected as a tense band by passing the tip of the finger inward along the deep aspect of Poupart's ligament. It will be more fully exposed at a later stage of the dissection; its relation to the femoral ring is shown on p. 202.

The **triangular fascia** (ligament of Colles or lig. inguinale reflexum), another extension of the aponeurosis of the external oblique, very thin and somewhat fan-shaped, is to be seen upon reflecting upward and inward the inner part of this aponeurosis (Fig. 293); it is continued from the attachment of Gimbernat's ligament to the pectineal line, upward and inward to the linea alba, behind the site of the external ring and in front of the conjoined tendon.

To summarize, the aponeurosis of the external oblique furnishes Poupart's ligament, Gimbernat's ligament, the triangular fascia, the inner and outer pillars of the external ring, the intercolumnar fibres and the intercolumnar fascia.

The removal of the external oblique, as above indicated, exposes the internal oblique muscle covered with a layer of fascia, in which and upon the surface of the muscle are the nerve-trunks mentioned above. Before removing the fascia from the surface of the internal oblique, these nerves should be identified and isolated. The **ilio-inguinal nerve** appears upon the surface of the internal oblique a little way above the middle of Poupart's ligament, and follows the course of the spermatic cord to the external abdominal ring, through which it passes. If the nerve be raised and slight traction be made upon it, its position after passing through the external ring will be revealed if it has not already been dissected in this situation. The **hypogastric branch** of the ilio-hypogastric nerve first appears upon the surface of the internal oblique a little farther up than the ilio-inguinal and about opposite the middle of Poupart's ligament, passing from this point forward and downward to pierce the aponeurosis of the external oblique near the external ring and slightly above and external to it; it then continues superficially in an upward direction toward the umbilicus. The **iliac branch** of the ilio-hypogastric nerve will be found above the crest of the ilium a few inches back of the anterior superior spine, while the **lateral cutaneous branch** of the last dorsal nerve will be seen in front of the latter, between it and the anterior superior spine; these two nerves were dissected in part previous to the reflection of the external oblique. **Terminal branches** of the lower seven intercostal nerves will be found piercing the internal oblique near its anterior aponeurosis or piercing the aponeurosis itself to enter the sheath of the rectus; the terminations of these nerves were encountered in dissecting the superficial fascia near the linea alba. The fascia should

now be removed from the surface of the muscle, the difficulty of the work being lessened somewhat by maintaining the tense condition of the muscle (by inflation of the abdominal cavity) and by thoroughly moistening the fascia.

Obliquus Internus Abdominis (Fig. 290).—**Origin,** the outer half of Poupart's ligament, the anterior two thirds of the crest of the ilium, the (posterior lamella of the) lumbar fascia; **insertion,** the most posterior fibres into the twelfth, eleventh and tenth ribs and by its anterior aponeurosis into the ninth, eighth and seventh ribs and the linea alba; the lowest fibres, those from Poupart's ligament, arching inward and

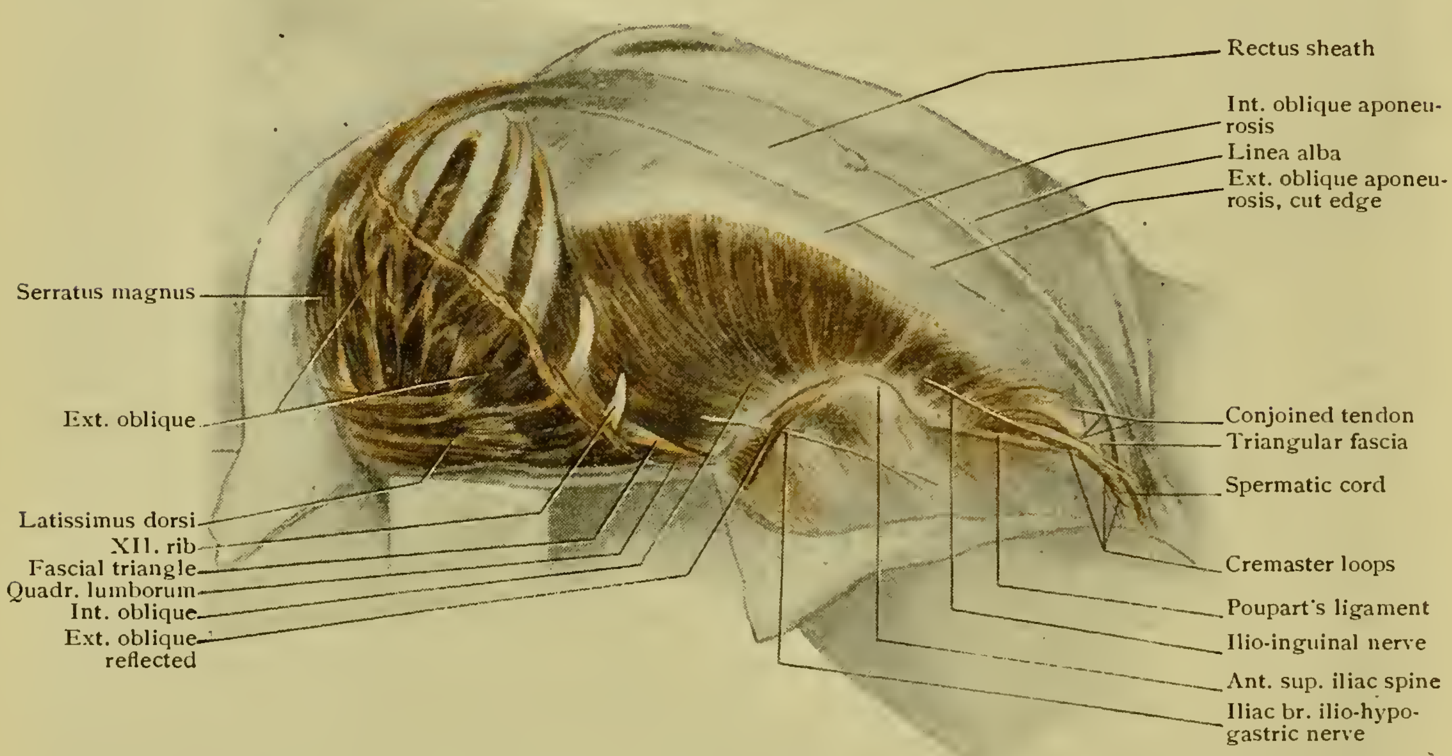

Fig. 290.—Dissection of obliquus internus abdominis.

downward to terminate in a tendon, the **conjoined tendon,** common to this muscle and to the transversalis, which tendon is inserted into the crest of the pubis and the ilio-pectineal line. **Nerve-supply,** the ilio-inguinal, the ilio-hypogastric and the lower four intercostal nerves. **Action,** compression of the abdominal contents as in the case of the external oblique (*q.v.*) and to aid in flexion and torsion of the trunk.

The **triangle of Grynfelt and Lesshaft,** in relation with the posterior border of the internal oblique, is bounded in front by that muscle, behind by the quadratus lumborum and above by the twelfth rib, while it is covered by the latissimus dorsi; it is called the *fascial triangle* because its floor is formed by the posterior aponeurosis of the internal oblique (Fig. 290).

The student will note that the internal oblique is inserted into the six lower ribs and that its **aponeurosis,** aside from that portion of it inserted into the ninth, eighth and seventh ribs, splits near the outer border of the rectus into two laminæ, the superficial layer blending with the aponeurosis of the external oblique to form the anterior wall of the sheath of the rectus, while the deep layer blends with the underlying aponeurosis of the transversalis to form the posterior wall of the sheath of the rectus. This applies to the upper three fourths of the extent of the rectus; throughout the lower fourth, the entire aponeurosis of the internal oblique together with that of the transversalis passes in front of the rectus (Figs. 278 and 295).

The Cremaster Muscle and Fascia.—The lower border of the internal oblique—which should now be examined—starting at the middle of Poupart's ligament describes an arch and encloses an area between the middle of Poupart's ligament and the spine of the pubis in which is found the rounded spermatic cord. Upon close examination it is seen that some of the lowest fibres of this muscle separate themselves from the main body of the muscle and follow the spermatic cord through the external abdominal ring to the testicle; these muscle fibres are known as the **cremaster muscle;** not sufficiently abundant to form a continuous layer, the intervals between the fibres are occupied by areolar tissue, the latter and the muscular fibres constituting then a continuous sheet which is known as the **cremasteric fascia** or **middle spermatic fascia.** Replacing temporarily the inner flap of the aponeurosis of the external oblique, this cremasteric fascia may be traced upon the spermatic cord, the intercolumnar fascia being removed for this purpose, and may even be traced downward to constitute one of the coverings of the testicle. If any one of the individual bundles of muscular fibres be traced from the middle of Poupart's ligament along the spermatic cord downward around the testis and then upward again on the inner side of the cord (Fig. 298), it will be seen to be attached to the pubic bone near the spine; hence the **origin** of the cremaster muscle is given as the middle of Poupart's ligament and its **insertion** as the os pubis.

The Conjoined Tendon.—Returning now to the lower border of the internal oblique, and gently and carefully elevating the spermatic cord to make this border more distinct, the lower fibres of the muscle may be traced to the conjoined tendon (Fig. 292). This tendon, receiving the lower fibres of both the internal oblique and the transversalis, appears as a rather strong, tense band, varying in width from three fourths of an inch to an inch and one fourth or more, attached to the crest of the pubis and the ilio-pectineal line. It is crossed by the triangular fascia (p. 603) and lies just behind the external abdominal ring, serving, therefore, to strengthen the abdominal wall at this point. If the dissector attempts to raise the conjoined tendon he will find that it is continuous

by its inner border with the external tendon of the rectus (p. 614) and by its outer border with the downward prolongation of the semilunar fold of Douglas; in addition the deep surface of the tendon is adherent to the fascia transversalis which lines the anterior abdominal wall. The conjoined tendon varies considerably in thickness as well as in other respects. It usually shows a thickening along its inner border and one along the outer border, it being especially in the intervening portion that the variation in thickness is apparent, this part of the tendon being so thin in some cases as to be almost nonexistent. A direct inguinal hernia, a hernia passing directly from the abdominal cavity through the external ring, may pass to the inner side of the tendon or may pass *through* a conjoined tendon which presents a very thin intermediate segment and so receive a contribution to its coverings from the conjoined tendon.

The space below the lower border of the internal oblique, between it and the inner half of Poupart's ligament upon which the spermatic cord rests, has for its floor the lining fascia of the anterior abdominal wall, the transversalis fascia, upon which, therefore, the spermatic cord rests.

The reflection of the internal oblique may now be effected by making a vertical incision near the beginning of its aponeurosis—the dissector taking care, however, to cut through only the internal oblique and not to include the transversalis—and terminating the incision just above the conjoined tendon. The muscle may also be incised near its attachment to the ribs and should now be carefully elevated and reflected, the fascia between it and the underlying transversalis serving as a guide to the interval between the two muscles. In making this dissection, regard should be had for the nerves and vessels that are to be found here, to avoid injuring which the knife should be kept close to the deep surface of the muscle. After the reflection of this muscle, the transversalis, covered with its layer of fascia and presenting upon its surface certain nerves and vessels, will be exposed (Fig. 291).

The **nerves** and **vessels** should be identified and isolated before attempting the removal of the fascia. The **ilio-hypogastric nerve** (Fig. 291) will be found near the crest of the ilium, the previously isolated iliac and hypogastric branches serving as a guide to its position; the trunk of the nerve should be traced to the point at which it pierces the transversalis. The anterior division of the **twelfth dorsal nerve,** the lateral cutaneous branch of which has been already dissected, will be found farther up just below the point of the twelfth rib, while emerging from the intercostal spaces, corresponding to the costal margin from the twelfth rib to the ensiform cartilage, will be seen the respective **intercostal nerves;** the latter nerves pass across the transversalis muscle, distributing *branches* to it and the internal oblique, to pierce the sheath of the rectus; their further course will be traced after opening the sheath

of the latter muscle. To further expose these nerves, the external intercostal muscles of two or three intercostal spaces should be cut through, which will also expose the corresponding **intercostal arteries,** both artery and nerve being near the upper margin of the corresponding space close to the rib, the nerve being below the artery. The **arteries** found in this muscular interval are *branches of the intercostal arteries* as just indicated, lower down some *branches of the lumbar arteries* and near Poupart's ligament the *deep circumflex iliac artery* (Fig. 293), a branch of the external iliac, which pierces the transversalis not far from the anterior superior spine of the ilium and curves upward and outward, dis-

FIG. 291.—Dissection of transversalis abdominis and of the lower six thoracic nerves and of the ilio-inguinal and ilio-hypogastric nerves, the external and internal oblique muscles being removed. The nerves are seen to give off their lateral cutaneous and muscular branches and to terminate in cutaneous filaments which perforate the sheath of the rectus.

tributing *muscular branches,* some of which have been encountered previously in the dissection of the external and internal oblique muscles. After the dissection of these structures, the fascia covering the transversalis muscle should be removed, the same remarks applying to its removal that were made concerning the dissection of the fascia covering the internal oblique.

TRANSVERSALIS (transversus abdominis) (Fig. 291).—**Origin,** the outer third of Poupart's ligament, the anterior two thirds of the crest of the ilium, the transverse processes of the lumbar vertebræ (by its posterior aponeurosis) and the deep surfaces of the six lower ribs, interdigitating with the costal origin of the diaphragm; **insertion,** by its *aponeurosis* into the linea alba and by its *conjoined tendon* into the crest of the pubis and the ilio-pectineal line. **Nerve-supply,** the ilio-hypo-

gastric and ilio-inguinal nerves and the lower six or seven intercostal nerves. **Action,** compression of the abdominal contents as in the case of the two preceding muscles.

The *posterior aponeurosis* has been examined (p. 585). The *anterior aponeurosis* will be seen to blend with the deep lamella of the aponeurosis of the internal oblique to form the posterior wall of the sheath of the rectus. The lowest fibres of the muscle, those arising from the outer

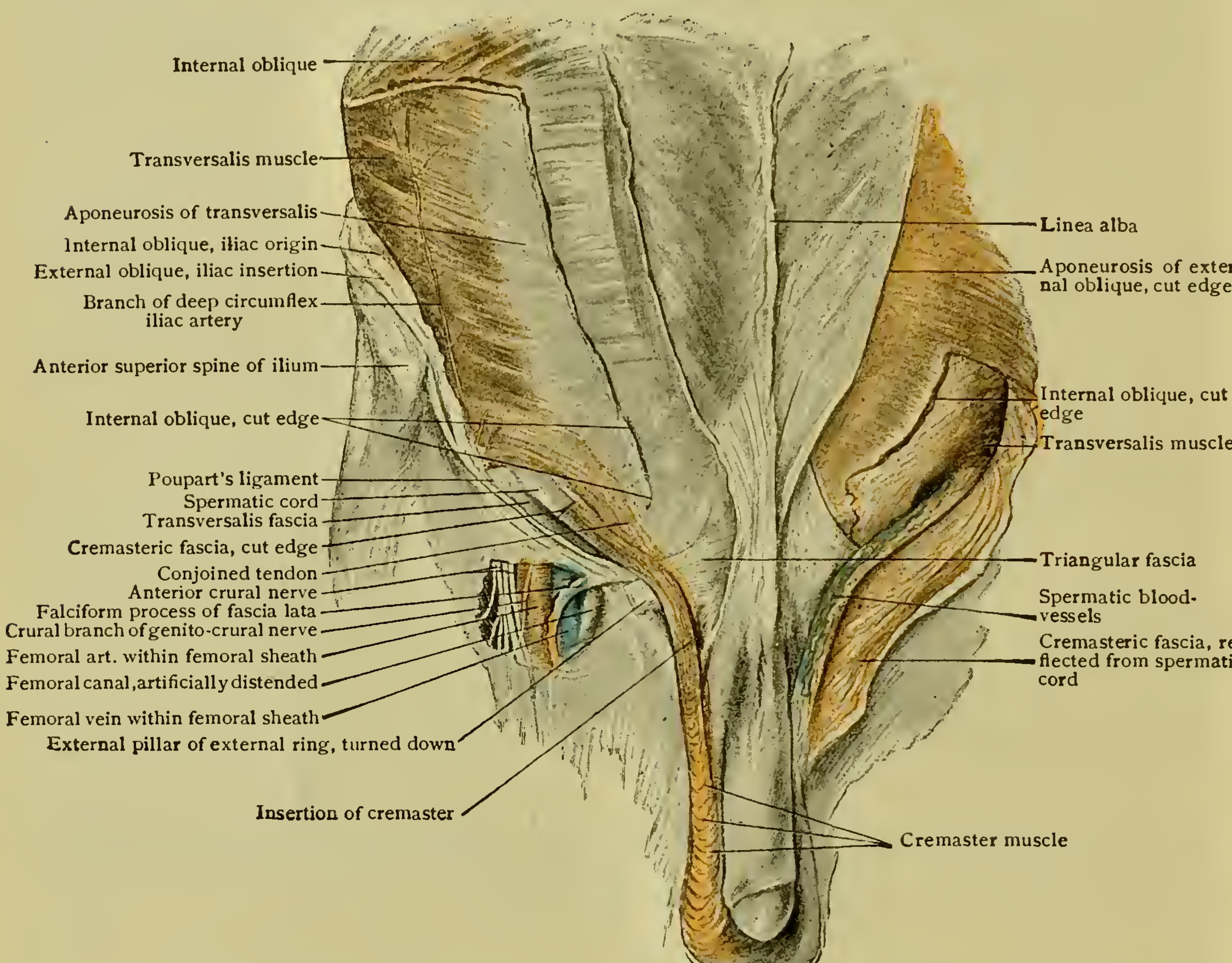

FIG. 292.—Internal oblique muscle has been partially removed, showing fibres of transversalis arching over spermatic cord to reach conjoined tendon; fascia lata has been opened to expose femoral vessels lying within sheath ; femoral canal has been artificially distended. Compare Fig. 101.

third of Poupart's ligament, as in the case of the internal oblique, are prolonged upon the spermatic cord as a part of the cremasteric fascia (p. 605). If the lower border of this muscle be carefully isolated and if the spermatic cord be gently raised, it will be seen that the lower edge of the muscle skirts the aperture, the internal abdominal ring, in the transversalis fascia through which the spermatic cord emerges (Fig. 292).

The **transversalis fascia** (p. 606) has been referred to as lining the anterior abdominal wall. It is therefore in relation with the deep surface of the transversalis muscle. While it is not desirable at this stage

of the dissection to expose it completely, it is necessary to consider it in part at this time on account of its relation to the inguinal canal. Again raising the spermatic cord, that is, that part of it which lies between Poupart's ligament and the lower borders of the internal oblique and the transversalis, this part of the transversalis fascia will be exposed (Fig. 101), and one may note that it is adherent to the deep surface of Poupart's ligament external to the middle point of the latter; internal

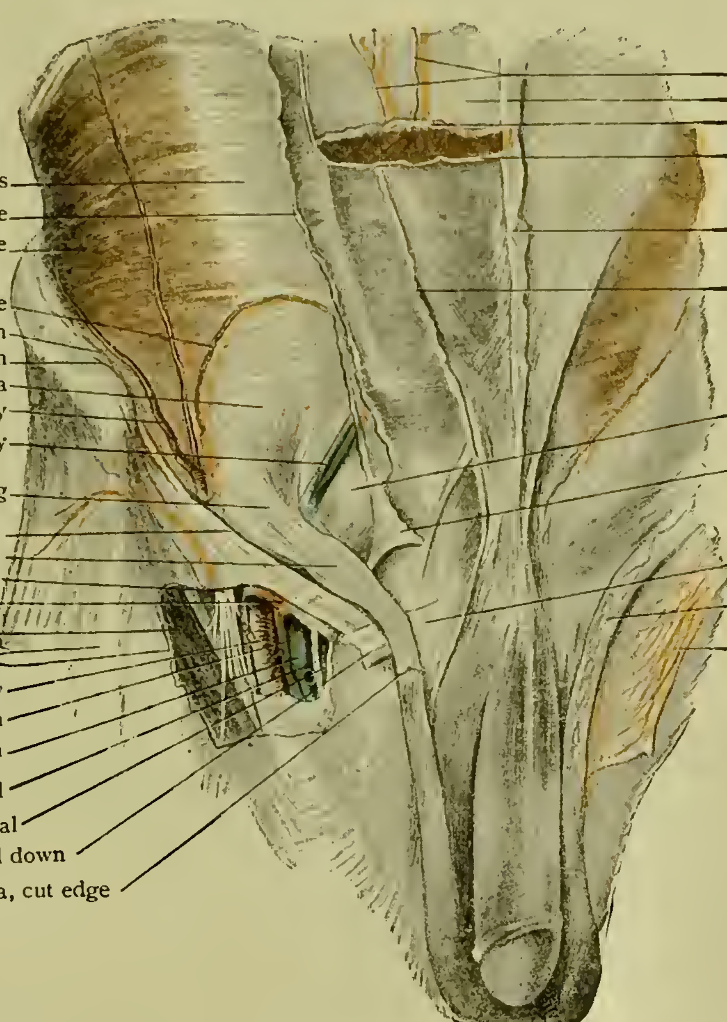

Fig. 293.—Transversalis muscle has been partially cut away to expose transversalis fascia; spermatic cord is seen issuing from internal abdominal ring, covered by infundibuliform fascia, which has been artificially distended; anterior layer of femoral sheath has been removed, showing femoral vessels and canal; anterior wall of sheath of rectus has been opened above, upper part of muscle removed and posterior wall of sheath exposed. Compare Fig. 102.

to this point it is prolonged into the thigh beneath Poupart's ligament to form the anterior wall or sheath of the femoral vessels (Fig. 103). In pulling slightly upon the spermatic cord it becomes evident that the transversalis fascia is prolonged upon it as a somewhat funnel-shaped process. This prolongation constitutes the **infundibuliform fascia** (Fig. 294) or **internal spermatic fascia,** which, as in the case of the other coverings of the cord, is prolonged upon the latter and upon the testicle. The circular orifice of the prolongation, at its point of continuity with the transversalis fascia, is the **internal abdominal ring** (annulus inguinalis abdominis) (Fig. 102). The internal abdominal ring is, therefore,

said to be an opening in the transversalis fascia, from the margins of which opening is prolonged the infundibuliform fascia.

The Inguinal Canal.—The inguinal canal is the space occupied by the spermatic cord between the internal and the external abdominal rings. Its length is therefore one inch and a half, the external ring, the superficial orifice of the canal, being just over the spine and crest of the pubes, while the internal ring, its abdominal orifice, is one half inch above the middle of Poupart's ligament. The immediate walls of the inguinal canal are the infundibuliform fascia and the cremasteric fascia. It is **bounded** in *front* throughout its entire length by the skin, the superficial fascia, the aponeurosis of the external oblique and, in its outer third, by the lower fibres of the internal oblique, the fibres of the transversalis arching just above the internal ring. It is bounded *behind* throughout its entire length by the transversalis fascia and the parietal peritoneum and in its inner third by the conjoined tendon.

While the inguinal canal in the male transmits the spermatic cord, in the female it transmits the round ligament of the uterus, which terminates in the labium majus (p. 709).

To appreciate the significance of the inguinal canal and the several layers of fascia considered above, one must take note of certain features of development. While these facts are considered elsewhere, it will be well to point out here that the scrotum is a pouched-out portion of the abdominal wall, prepared in advance for the lodgment of the testes, which descend from the site of their development in the lumbar regions of the abdomen to reach and traverse the inguinal canal in the last month of gestation. Hence we have in the skin and dartos of the scrotum the representatives of the skin and superficial fascia of the abdominal wall, while the aponeurosis of the external oblique is represented by the intercolumnar fascia, the internal oblique and transversalis muscles by the cremasteric fascia, and the transversalis fascia by the infundibuliform fascia. The parietal peritoneum of the abdominal wall is represented by the tunica vaginalis testis.

It will be evident that if the spermatic cord perforated the abdominal wall directly instead of obliquely, that is, if the internal ring—the site of the perforation of the innermost layer—coincided in position with that of the external ring, the strength of the wall would be much impaired. Inasmuch, however, as the openings in the respective layers do not coincide in position this result is in a measure avoided. But notwithstanding the effort to conserve the resisting power of the abdominal wall, it is weakened somewhat by the passage of the spermatic cord through it. This is evidenced by the occurrence of **inguinal hernia,** which is a protrusion of a portion of intestine or omentum through one or both of the abdominal rings either as a result of extraordinary intra-abdominal pressure overcoming a normal resistance, or of a less degree

of pressure overcoming weakened resisting power on the part of the tissues at the margins of the rings.

An **indirect** or **oblique inguinal hernia** is one that leaves the abdominal cavity by passing through the internal ring; if it remains in the inguinal canal it constitutes an *incomplete hernia* (bubonocele); if it traverses the entire canal and reaches the scrotum it constitutes a *complete hernia*. The **coverings** of such a hernia are, in the order of acquirement, the peritoneum, forming its *sac*, the subserous areolar tissue, the infundibuliform fascia, the cremasteric fascia, the intercolumnar fascia, the superficial fascia and the skin.

FIG. 294.—Deep dissection of inguinal region, internal abdominal ring and Hesselbach's triangle.

A **direct hernia** is one that passes through the external ring, or directly into the terminal part of the inguinal canal without traversing the internal ring. The **coverings** of such a hernia are, in the order of acquisition, the parietal peritoneum, forming the *sac*, the subserous areolar tissue, the transversalis fascia (instead of its infundibuliform process), the conjoined tendon (instead of the cremasteric fascia), the intercolumnar fascia, the superficial fascia and the skin. Comparing what was said on page 605 of the varying character of the conjoined tendon, it will be evident that a direct inguinal hernia may or may not derive one of its coverings from that structure. Certain special varieties of inguinal hernia are considered on page 624.

HESSELBACH'S TRIANGLE (Fig. 294).—**Boundaries:** on the inner side, the outer border of the rectus; externally, the deep epigastric ar-

tery; below, Poupart's ligament. This triangular space is exposed upon reflecting the lower portion of the transversalis muscle and aponeurosis. The space is of interest by reason of its relation to inguinal herniæ, a direct hernia protruding through this triangle, while an oblique one necessarily enters the inguinal canal beyond the outer limit of the triangle.

The **deep epigastric artery** arises from the external iliac as that vessel passes under Poupart's ligament to become the femoral artery. Passing upward and inward as the outer boundary of the triangle of Hesselbach, it pierces the transversalis fascia and enters the sheath of the rectus muscle, its further course within which will be followed after opening the sheath of the rectus. The relation of the deep epigastric artery to the inguinal rings and, consequently, to the operations for the relief of strangulated inguinal hernia, is of importance. Since the vessel arises beneath the middle of Poupart's ligament and passes upward and inward, it lies upon the inner side of the internal ring and upon the outer side of the external ring.

Since it is not always possible to determine before operation for inguinal hernia whether one is dealing with a direct or an oblique variety, owing to the fact that in an oblique hernia of long standing the inguinal canal may be almost obliterated, the internal ring being closely approximated to the external ring by traction exerted by the mass, it is necessary, in order to avoid injury to the deep epigastric artery, to make the incision for the division of the constriction directly upward in a line parallel with the long axis of the body.

The Rectus Abdominis (Fig. 295).—**Origin,** by a small internal head from the pubic symphysis, and a larger outer head from the crest of the pubis; **insertion,** the fifth, sixth and seventh ribs; **nerve-supply,** the lower seven intercostal nerves; **action,** compression of the abdominal contents and flexion of the trunk.

The **sheath of the rectus** has been exposed (Fig. 290). Reference to Fig. 278 will show that the *anterior wall* of the sheath is composed of the aponeurosis of the external oblique united with the anterior layer of the aponeurosis of the internal oblique, while the *posterior wall* is formed by the deep layer of the aponeurosis of the internal oblique united with that of the transversalis. As stated previously, the posterior wall is deficient in its lower fourth, since, in this part of the abdomen, the aponeuroses mentioned pass entirely in front of the muscle, this lower fourth of the muscle being in contact, therefore, with the transversalis fascia. The **semilunar fold** of Douglas will be seen after the opening of the sheath.

The sheath of the rectus should now be incised by a longitudinal cut from a point near the ensiform cartilage, curving inward somewhat at its lower extremity to terminate at the symphysis pubis. The anterior wall of the sheath should be reflected from each side of this incision.

This will be done without difficulty except at the lines of the **transverse tendinous intersections,** the **lineæ transversæ** (inscriptiones tendineæ) to which the sheath is intimately adherent. These tendinous intersections, of which one is found near the umbilicus, one near the ensi-

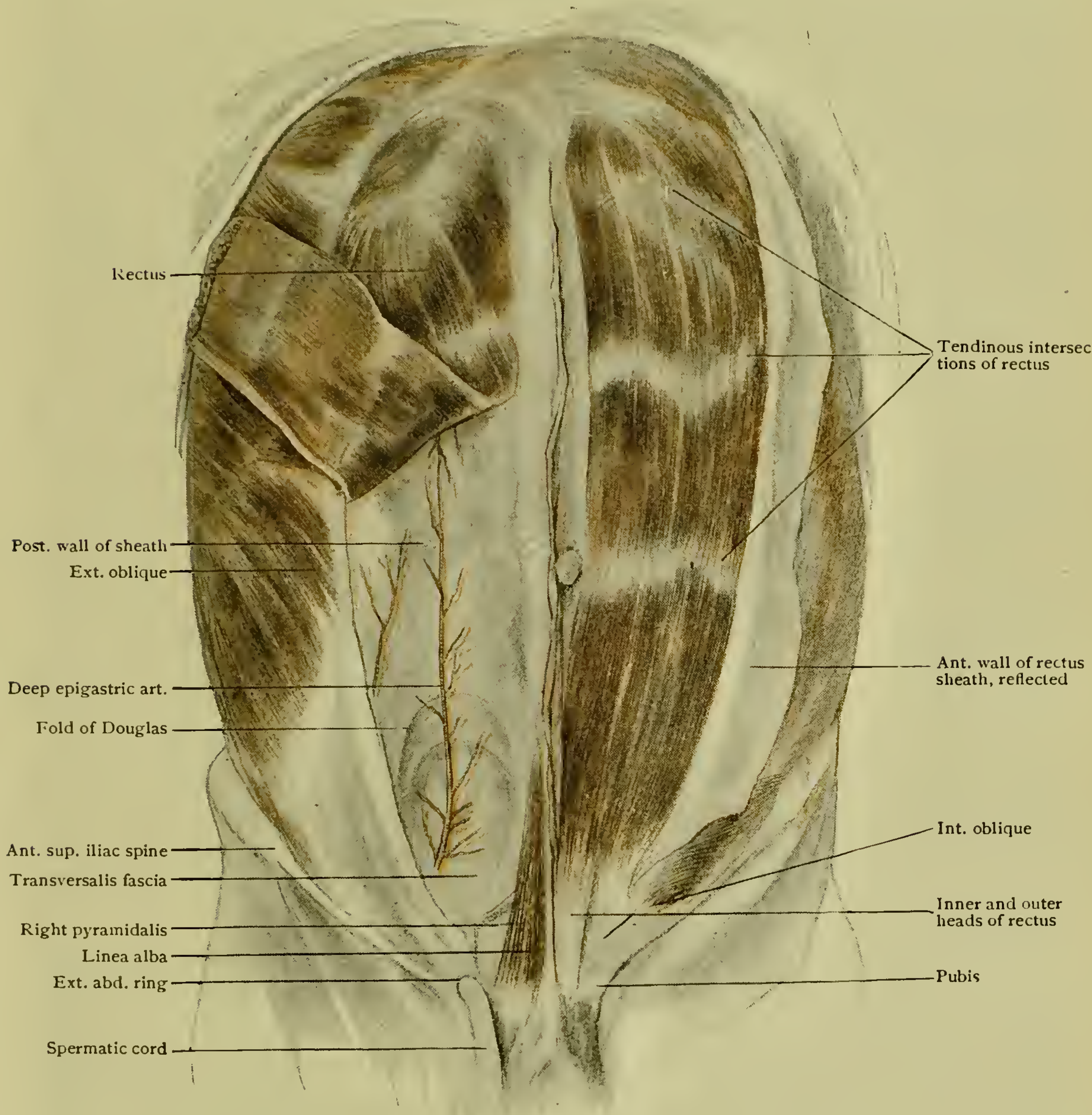

FIG. 295.—Dissection of rectus abdominis and its sheath.

form and a third approximately midway between these two, divide the muscle into four sections, thus enabling different portions of the length of the muscle to act more or less independently.

The **pyramidalis muscle** (Fig. 295) in the lower part of the sheath of the rectus should be examined before the rectus itself is disturbed.

The **origin** of the pyramidalis is the pubic body and symphysis, the muscle passing upward and inward to be **inserted** into the linea alba at some point between the pubis and the umbilicus. This muscle is sometimes absent on one or both sides.

The rectus should now be elevated with the fingers, thus demonstrating that the tendinous intersections are not adherent to the posterior wall of the sheath, when the muscle may be divided by a transverse cut and slowly reflected in order to discover the *nerve-trunks* that enter its deep surface, and in order also not to disturb the *blood-vessels* in relation with this surface. The **posterior wall** of the sheath is now exposed (Fig. 295) and is seen to terminate at some point below the umbilicus in a margin which is concave downward; this is the **semilunar fold of Douglas.** An effort made to elevate the edge of this fold upon the scalpel handle will demonstrate that the sheath is quite adherent to the underlying transversalis fascia. Nevertheless, the two structures may, with care, be separated. The inner horn of the semilunar fold is prolonged downward to blend with the thickened inner border of the conjoined tendon, the **ligament of Henle** (falx inguinalis); the outer horn of the crescent blends with the outer border of the conjoined tendon to form the **ligament of Hesselbach** (lig. interfoveolare).

The **deep epigastric artery** (p. 612) enters the sheath of the rectus by passing over the semilunar fold of Douglas (Fig. 295) and may usually be traced upward in relation with the posterior wall of the sheath to its anastomosis with the **superior epigastric artery,** one of the terminal branches of the internal mammary from the subclavian artery, noteworthy as the longest anastomosis in the body. The **branches** of the deep epigastric are a *pubic branch*, passing to the abdominal aspect of the pubic symphysis; a *cremasteric branch*, entering the inguinal canal to accompany the spermatic cord; *muscular branches* to the rectus and *cutaneous branches*. Occasionally the *obturator artery* arises from the beginning of the deep epigastric.

The Transversalis Fascia.—The transversalis fascia lines the anterior and lateral portions of the abdominal wall, blending posteriorly with the fascia covering the upper part of the psoas and with the anterior layer of the lumbar fascia. It is attached along the inner lip of the crest of the ilium and along the line of Poupart's ligament from the anterior superior spine of the ilium to the position of the femoral artery, in which situation it blends with this ligament and with the iliac fascia of the iliac fossa. Where the femoral artery and the femoral vein begin as continuations of the external iliac artery and vein respectively, the transversalis fascia is prolonged into the thigh upon the anterior surfaces of these vessels (Fig. 103) to form the anterior wall of their sheath. As pointed out above, it is adherent to the aponeurosis of the transversalis muscle and to the conjoined tendon. The internal abdominal ring,

an aperture in this fascia opposite the middle of Poupart's ligament, has also been described, as well as the infundibuliform process, which is the continuation of the fascia upon the spermatic cord. The transversalis fascia may be exposed by making a transverse incision through the transversalis muscle at the level of the umbilicus and carefully elevating the part of the muscle above this incision from the underlying fascia, not, however, disturbing the lower part of the muscle for reasons which will appear later.

The **parietal peritoneum** of the anterior abdominal wall may be demonstrated in part by making a transverse incision through the transver-

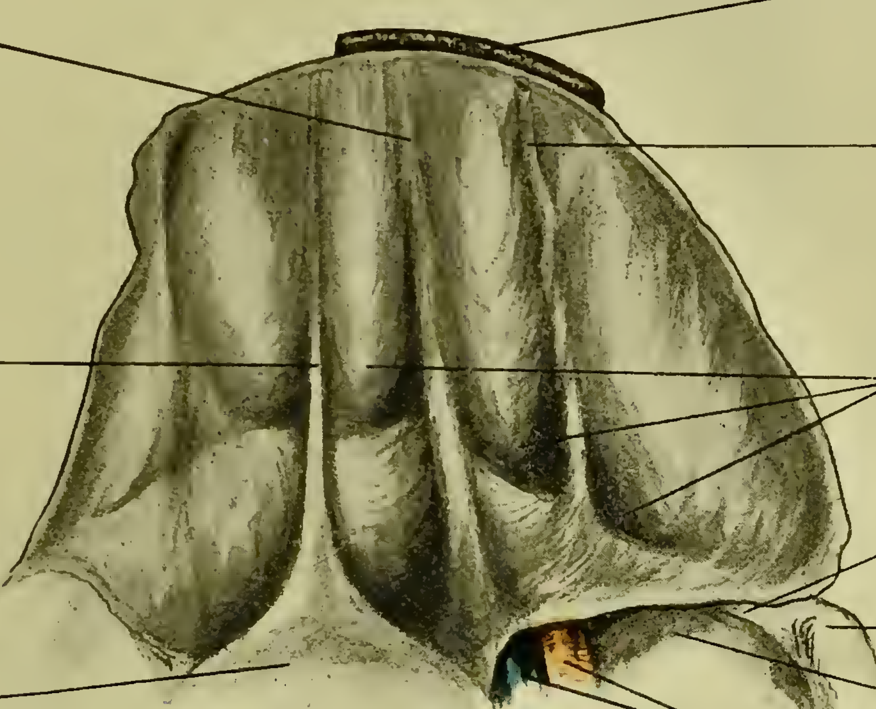

FIG. 296.—Inner surface of lower part of anterior wall of abdomen.

salis fascia at the level of the umbilicus and carefully elevating the part of the fascia above this incision. In doing this a small amount of loose tissue, the **subserous** or **subperitoneal areolar tissue,** will be encountered lying between the transversalis fascia and the parietal peritoneum. The looseness of this tissue, responsible for the ready spreading of pus between the parietal peritoneum and the abdominal wall, may be demonstrated by separating the transversalis fascia to as great extent as the limits of the dissection will allow.

THE INNER ASPECT OF THE LOWER ABDOMINAL WALL.—The transverse incision already made at the level of the umbilicus should now be completed by carrying it across the sheath of the rectus and the linea alba through the centre of the umbilicus and making it deep enough to include the parietal peritoneum. This may be supplemented by two

lateral incisions, one on each side, extending vertically upward from the junction of the outer third with the middle third of Poupart's ligament. To guard against injuring the viscera in making the lateral incisions, it will be well to elevate the part of the anterior wall thus outlined and make the lateral cuts from within outward. The part of the anterior wall thus defined should now be turned downward to permit the examination of its inner aspect. A median ridge on this surface is produced by the **urachus,** an obliterated portion of the allantois passing from the summit of the bladder to the umbilicus (Fig. 296). The fold of perito-

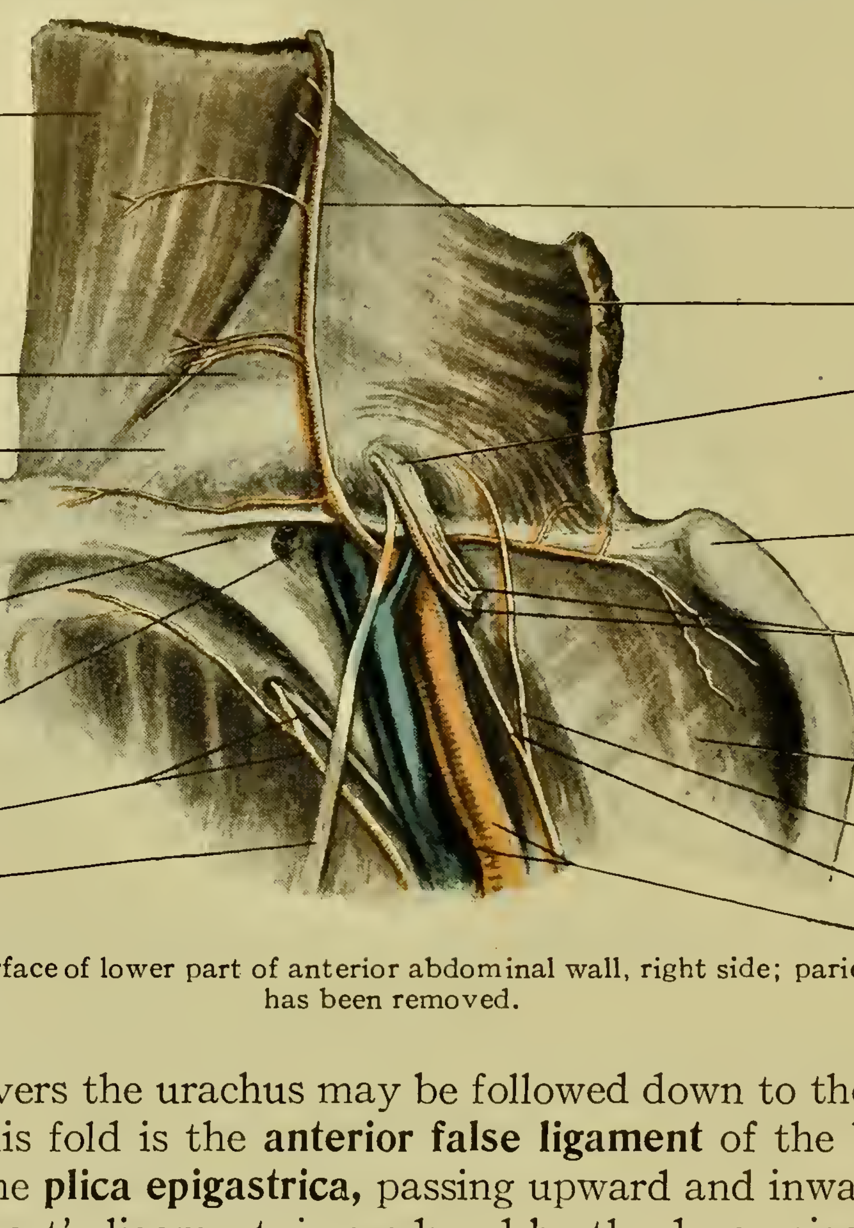

Fig. 297.—Inner surface of lower part of anterior abdominal wall, right side; parietal peritoneum has been removed.

neum which covers the urachus may be followed down to the summit of the bladder; this fold is the **anterior false ligament** of the bladder. A second ridge, the **plica epigastrica,** passing upward and inward from the middle of Poupart's ligament, is produced by the deep epigastric artery (Fig. 297), and a third elevation between these two, the **plica hypogastrica,** is due to the obliterated fetal hypogastric artery extending from the upper part of the bladder to the umbilicus. These several ridges throw into relief corresponding depressions or fossæ, the most external of which is the **external inguinal fossa** which corresponds to the position of the internal abdominal ring. The **inner inguinal fossa,** bounded externally by the deep epigastric artery and internally by the obliterated hypogastric artery, indicates the place of exit of that variety of

direct inguinal hernia which passes to the outer side of the conjoined tendon. The **innermost** or **supravesical fossa,** bounded without by the obliterated hypogastric artery and mesially by the urachus, corresponds in position with the external abdominal ring and is traversed by that form of direct hernia which passes through the conjoined tendon.

THE MALE EXTERNAL GENITALIA.

THE PENIS.—The **root** or proximal end of the penis was seen, in dissecting the perineum, to be attached to the rami of the ischia and pubes by the diverging crura of the corpora cavernosa and to the triangular ligament by the bulb of the spongy body. The *skin* of the **body** of the organ is seen to be of delicate texture, of dark hue, without hairs and freely movable, while upon the **head** or **glans** (Fig. 299) it is closely bound down and resembles mucous membrane. The fold of the skin at the neck, the **prepuce** or **foreskin,** is variably redundant and is connected with the glans near the posterior end of the vertical slit, the **meatus urinarius,** by a median fold, the **frenum.**

The *looseness of the skin* of the penis favors swelling in œdema or in inflammatory conditions. Unusual redundance of the prepuce is often associated with constriction of its orifice, constituting *phimosis* and calling for *circumcision.* The close adherence of the skin of the glans and the absence of subcutaneous tissue prevent the development of the characteristic induration of the *hard chancre* when this occurs on the glans; when occurring at or back of the corona glandis, the typical nodular induration is present. A congenital defect in the form of a median dorsal fissure or furrow exposing the urethra, **epispadias,** is sometimes seen; a similar defect in the floor of the urethra, from non-union of the fetal genital folds, is **hypospadias.** The latter may implicate the entire length of the penis or only the glans, **glandular hypospadias;** the meatus occupies its usual position in such cases but is functionless, the abnormal opening serving as the real orifice of the urethra.

The corpora cavernosa may be moderately distended by the injection of colored starch-mass with the larger hypodermatic syringe, several punctures being made on each side.

The **dissection** of the penis should be begun by making a median dorsal incision from the symphysis pubis to the corona glandis, the organ first being placed upon a board of suitable size laid across the fronts of the thighs, the foreskin being stretched out transversely and anchored to the board with push-pins.

The **skin** should now be reflected and its elasticity noted. The skin-flaps should be turned back and fastened to the board with push-pins.

The Superficial Fascia.—The superficial fascia, the **fascia penis,** now exposed, is seen to consist of the dense white *suspensory ligament of the penis,* extending from the pubic region to the root of the organ, and of the thin transparent *sheath of the corpus penis.* The **suspensory ligament** (Fig. 100) includes a *superficial elastic portion* that divides at

the front of the penis to become continuous around its sides with the scrotal septum, and a *deeper fibrous part* that blends with the tunica albuginea (*vide infra*).

The **superficial dorsal vein,** which drains into the superficial external pudic vein, often placed to one or other side of the mid-line and sometimes double, is now visible; the **deep dorsal vein** (Fig. 287) if injected

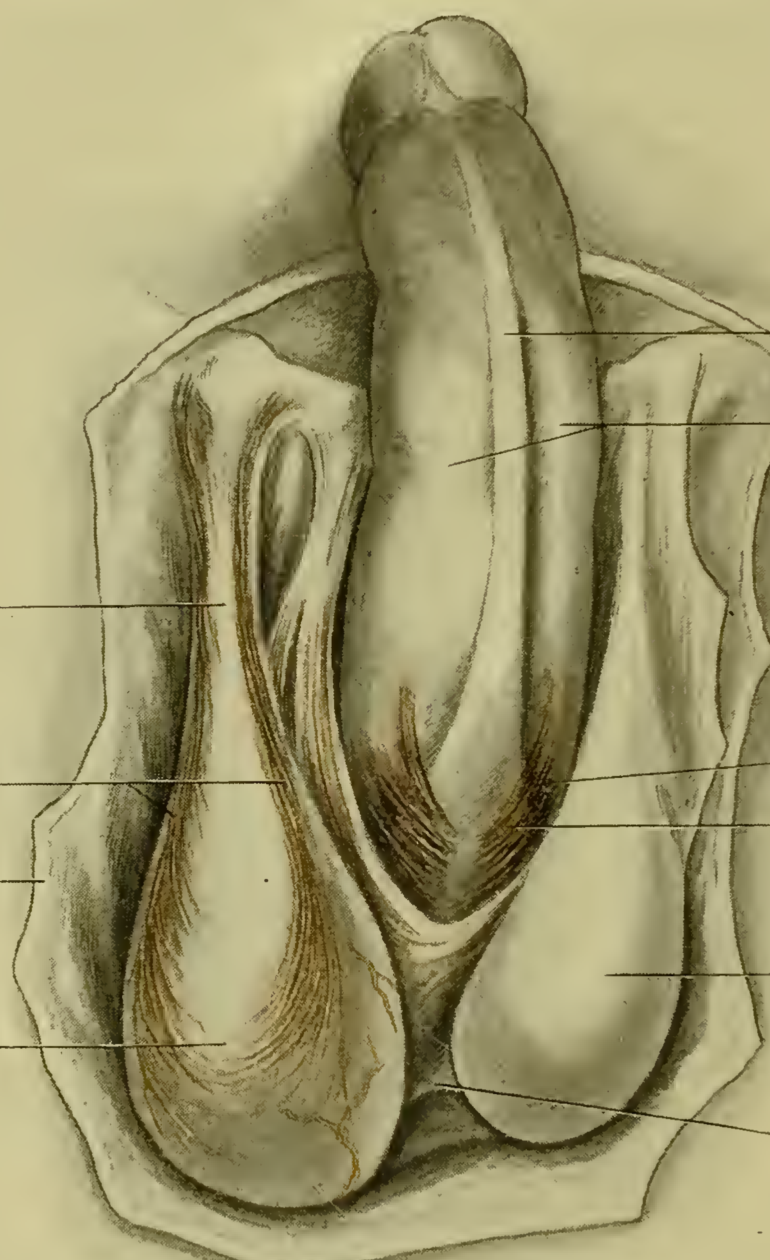

Fig. 298.—Superficial dissection of penis and testes, the spongy and cavernous bodies having been distended.

will also be seen through the overlying fascia; indeed, both vessels may usually be recognized in the living subject.

The **superficial layer** of the fascia, the **dartos,** should now be reflected from the mid-line and pinned back, its elasticity and entire freedom from fat being noted, as well as its muscular fibres. The muscular fibres, the **dartos,** are found more particularly on the under part of the penis and, although closely connected with the skin, will have been removed with the flap of fascia.

The **superficial external pudic artery** (p. 194) will be seen passing upon the proximal part of the organ at this stage.

The **deeper layer of fascia,** also free from fat and containing elastic tissue, should be removed in the same way, with due regard for the subjacent vessels and nerves.

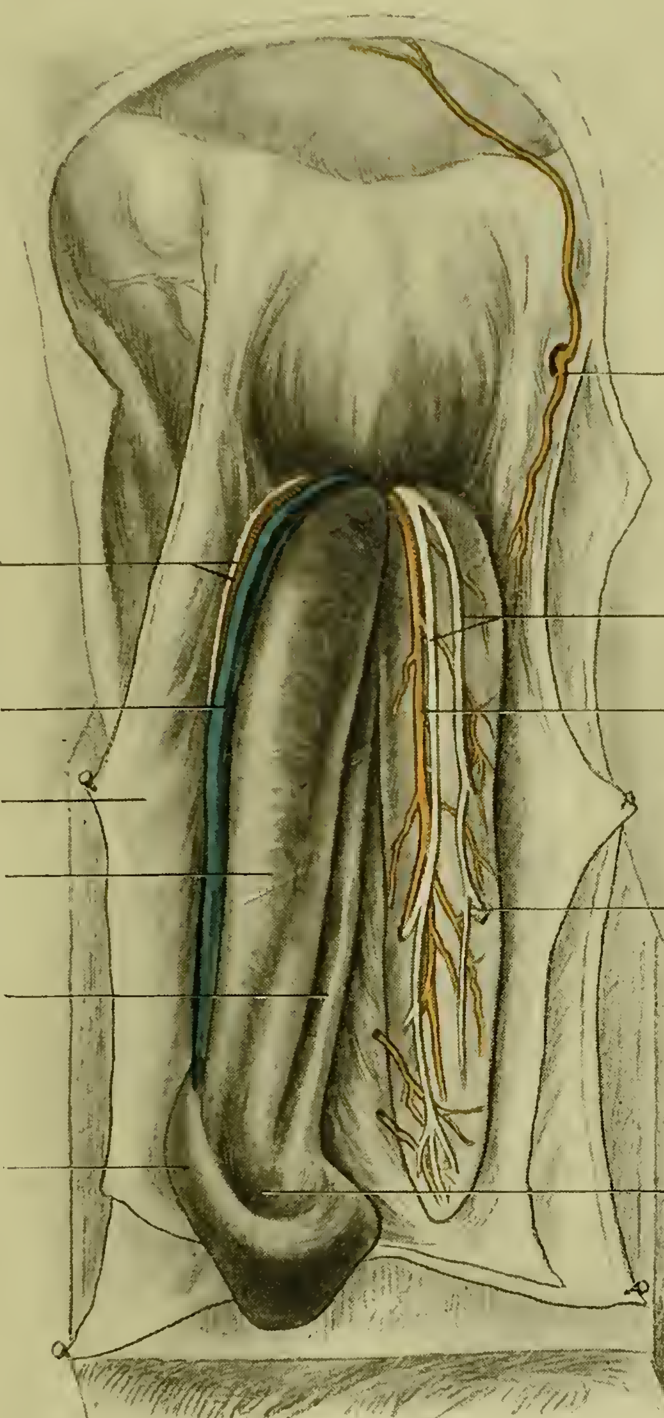

FIG. 299.—Deep dissection of penis, left cavernous body separated from the right. Cavernous and spongy bodies distended.

The Dorsal Vein, Arteries and Nerves.—The **deep dorsal vein of the penis** (Fig. 299) is an unpaired vessel of large size. It should be followed forward to its *origin* in two converging trunks, and backward to the root of the penis, between the superficial and deep parts of the suspensory ligament, to the triangular ligament (p. 571). Its many *tributaries* from the prepuce, glans and body of the penis will scarcely be found except in a specially injected subject.

The **dorsal nerve of the penis** (p. 564) should be picked up at the root of the organ where it pierces the suspensory ligament (Fig. 299) and traced forward to the glans along the outer side of the dorsal artery. Its *branches*—some penetrating the corpus cavernosum, others curving obliquely forward and laterally around the penis—will be more easily found if the proximal part of the trunk be picked up and slightly pulled.

The **dorsal artery of the penis** (p. 568) is to be denuded from its point of emergence through the suspensory ligament (Fig. 299) to its *termination* at the glans, where it divides into *two branches* for the glans and prepuce. The *branches to the corpus cavernosum* should also be noted, as well as the position of the vessel between the dorsal vein and the dorsal nerve.

The Corpus Penis.—The body of the penis, consisting of the two *corpora cavernosa* and the *corpus spongiosum* (Fig. 298), the latter enclosing the urethra, should now be fully exposed by removing all remnants of the superficial fascia from the dorsum, sides and under surface.

The **tunica albuginea** is now seen as a dense white membrane enclosing the corpora cavernosa.

The **corpus cavernosum** of one side should now be separated from its fellow (Fig. 299) to demonstrate the **septum pectiniforme,** the part of the albuginea between the cavernous bodies, and the blunt-pointed distal end of the spongy body fitting into the proximal surface of the glans (Fig. 299). Tracing the cavernous body toward the perineum, its posterior termination in the *crus penis* (Fig. 270) will be noted (p. 568), as well as the entrance into this of the artery and nerve of the corpus cavernosum. The *cavernous* or *spongy structure* of the cavernous bodies is demonstrated by the presence of the injection-mass. In a well-injected subject, the tortuous *helicine arteries* may be found in association with the trabeculæ of the spongy network.

The **corpus spongiosum** (Fig. 298) is now also seen as a rather slender cylinder terminating distally in the enlarged **glans** (Fig. 299), the relation of which to the corpora cavernosa has been seen, and ending behind in another enlargement, the **bulb** (p. 567).

Nothing further need be done with these structures until after the study of the pelvic viscera, when the spongy part of the urethra will be examined (p. 703). They should be carefully wrapped and preserved for further study.

The **veins** of the penis are the superficial dorsal vein, the deep dorsal vein and veins that pass directly to the prostatic plexus (Fig. 334).

The Scrotum.—The **median raphe** of the scrotum, significant of its development from two originally separate parts which remain distinct in the female to constitute the labia majora, should be noted as a median ridge from which diverge the wrinkles presented by the skin when contracted.

The dissection may be begun by making an incision on each side over the spermatic cord (Fig. 99) and coinciding with its long axis. The scrotum should now be placed on a board laid across the thighs, its distal end being stretched from side to side and fixed to the board with push-pins. The skin incision should be extended to the lower end of the sac and the skin dissected back from the incision both laterally and medially.

The Superficial Fascia.—The superficial fascia or **tunica dartos** is now exposed. The discoloration seen is due to the fibres of the **dartos muscle,** which are intimately associated with the skin and which may be traced inward to be connected with the **septum scroti,** the partition dividing the scrotal sac into lateral halves. The superficial fascia of the scrotum is noteworthy in that it is free from fat and contains elastic and muscular tissue.

The **superficial layer** of the superficial fascia may be reflected from an incision coinciding with the skin incision previously made. It was shown, in the dissection of the abdominal wall, to be continuous with Camper's fascia and, in the dissection of the perineum, with the superficial layer of the superficial fascia of the urethral triangle.

The **deep layer** of the superficial fascia may be reflected in the same manner. It has been seen (pp. 599 and 566) to be continuous above with Scarpa's fascia of the abdominal wall and with Colles's fascia of the perineum.

The **tunica dartos,** by reason of its elastic and muscular elements, causes the *wrinkling of the skin* of the scrotum, this condition being accentuated under the influence of cold and practically effaced in conditions of system relaxation. The looseness of the subcutaneous tissue favors *œdematous swelling.*

The continuity of the two layers of the dartos with the corresponding strata of the urethral triangle and of the abdominal wall explains the course taken by urine effused into the superficial perineal interspace—a course forward into the scrotum and then upward along the spermatic cord to the abdominal wall.

THE TESTICLE.—To expose the testicle, the male sexual gland, its **coverings,** incidentally referred to above (p. 610), must be removed. The most superficial coverings, the skin and dartos of the scrotum, having been removed, the proper testicular envelopes, those derived from the abdominal wall, are now accessible. In removing these, the spermatic cord will also be exposed, since the same strata invest that structure.

The Coverings of the Testis.—The **intercolumnar fascia** (intercrural or external spermatic fascia), an attenuated prolongation of the external oblique aponeurosis (p. 602), is to be reflected from either side of an incision along the front surface of the spermatic cord and testicle (Fig. 300). It will in some cases be difficult or impossible to do this. It can usually be effected, however, if the parts are well moistened and the flap be partly dissected, partly peeled off, the demonstration of the fascia which was made previously (p. 602) assisting in its identification.

The **cremasteric** or **middle spermatic fascia** (Fig. 293), representing the internal oblique and transversalis muscles (p. 605), should be reflected in similar manner.

The **infundibuliform** or **internal spermatic fascia** (Fig. 293), the tubular extension of the transversalis fascia (p. 609), is to be turned

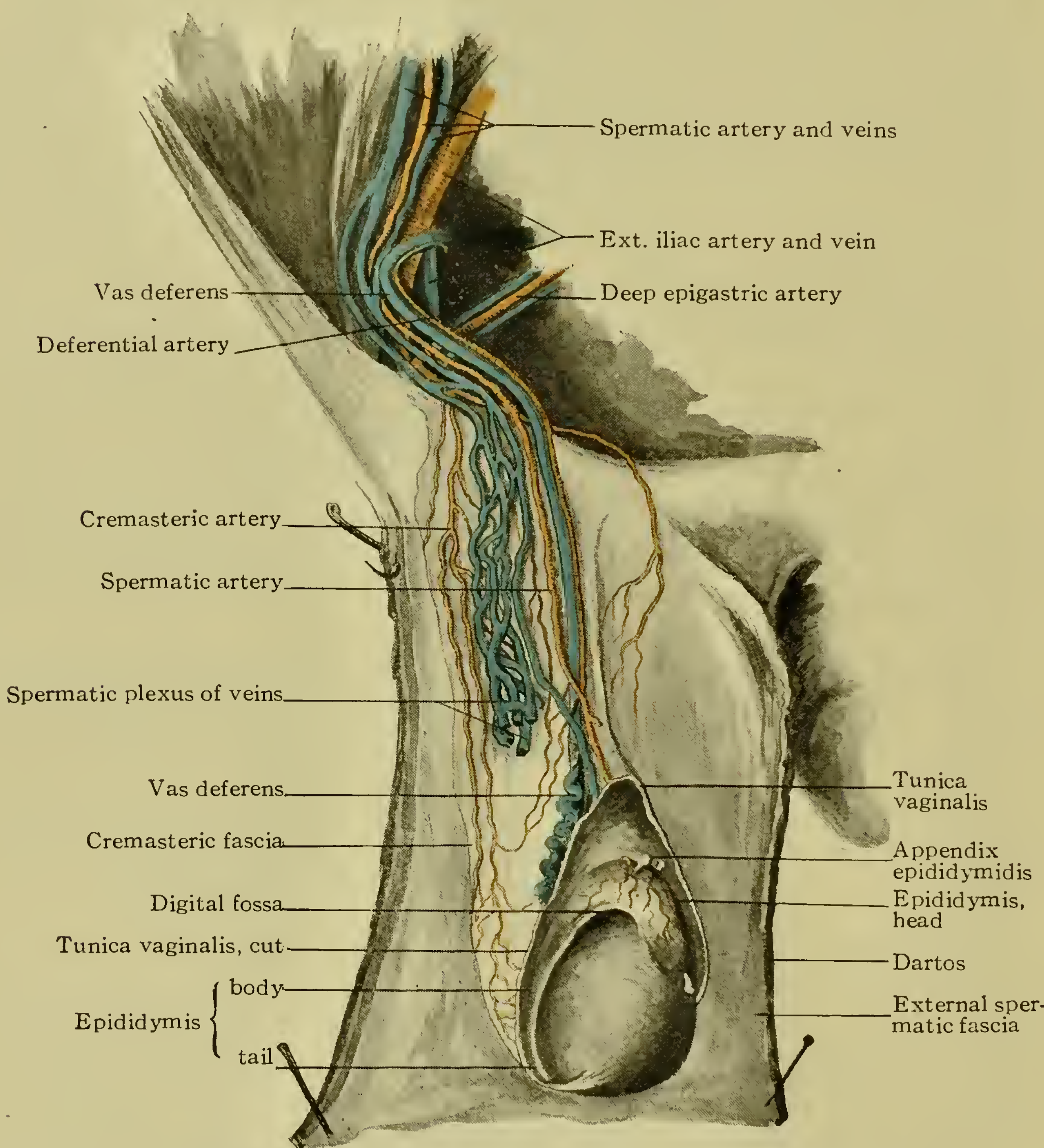

FIG. 300.—Dissection of spermatic cord showing lateral surface of right testicle.

back in the form of flaps as directed above. Between this fascia and the succeeding layer, at the back of the testis, is a stratum of muscular tissue, the **internal cremaster,** attached below to the scrotal ligament (Fig. 301), and spreading out above into the spermatic cord.

The Tunica Vaginalis Testis.—The tunica vaginalis, or serous covering of the testicle, may be demonstrated by pinching up a fold of the

parietal layer of the membrane from the front of the gland with forceps and injecting the cavity with water, taking care to avoid puncturing the testicle with the needle (Fig. 298). This brings the *parietal layer* into prominence and shows that the tunic invests the lower half-inch of the spermatic cord. The **scrotal ligament,** the mass of tissue connecting the lower part of the tunica and of the testis with the superficial envelopes of the testicle, the remains of the gubernaculum testis, may now be examined (Fig. 301).

To appreciate the anatomy of the tunica vaginalis it is necessary to take note of certain facts of development. Previous to the migration of the testicle from the site of its development in the lumbar region of the abdomen, the anterior abdominal wall is evaginated to form the coverings of the testicle noted above. The accompanying evagination of the parietal peritoneum constitutes the **processus vaginalis,** the pedicle of which is the **funicular process.** The testicle, guided by the genito-inguinal ligament, the later **gubernaculum testis,** a mass of muscular tissue enclosed by the lower part of the mesorchium or peritoneal fold that envelops the developing testis, reaches the internal abdominal ring and finally passes through the inguinal canal near the end of the ninth fetal month, behind the processus vaginalis. According to Cunningham, the testicle, carrying its own investment of peritoneum, the future *visceral layer* of the tunica vaginalis, passes *into* the tubular processus vaginalis, though it would seem, if this were true, that the post-peritoneal position of the spermatic artery, which lengthens as the testicle descends, would not be accounted for. When the testicle reaches the scrotum, the processus vaginalis folds around and acquires connection with it, the parietal and visceral layers of the serous investment thus being differentiated. The funicular process normally becomes obliterated, its vestige being a slender cord. This the dissector should try to find on the anterior surface of the spermatic cord by separating the constituents of the latter at the inner aspect of the internal abdominal ring. If the processus vaginalis does not suffer obliteration but remains patulous, the cavity of the tunica vaginalis remains in direct continuity with the general peritoneal cavity. Subvarieties of a patulous funicular process are those cases (a) where it closes at its proximal extremity but remains open elsewhere and (b) where it closes at its distal end but remains open above this point.

The varieties of persistent funicular process are associated respectively with the occurrence of certain forms of inguinal hernia. When the entire funicular process remains open, the cavity of the tunica vaginalis being in free communication with the abdominal peritoneal cavity, a loop of bowel may descend through the process into the tunica vaginalis, the latter constituting the sac of the hernia; this is called a **congenital hernia,** though it is the anatomical condition permitting of

its easy development that is congenital and not necessarily the hernia, since the latter may not appear until adult life.

The descent of intestine into a patulous funicular process that is closed at its distal end is a **funicular hernia;** the funicular process forms the hernial sac.

When the funicular process is closed only at its proximal extremity a portion of the bowel may push before it the parietal peritoneum at the site of closure to form its sac and descend behind the funicular process; this is called **infantile hernia.** In such a hernia three layers of serous membrane are in front of the hernia, its own proper sac and two layers of the funicular process. This variety is sometimes also called **encysted hernia,** though the latter term is restricted by some writers to the supposed cases where the upper, closed end of the funicular process is invaginated or inverted by a descending hernia, which would thus be surrounded by a double sac.

The spermatic cord may now be examined in a general way with the view of noting the relations of its vessels and of the spermatic duct to the testicle, so far as this may be done without dissection. The duct is to be found on the posterior surface of the cord and should be traced to the lower part of the testicle.

The **cavity of the tunica vaginalis** should now be laid open by cutting the front of the parietal layer with scissors (Fig. 300). It may then be seen that the parietal layer passes upon the gland to become the visceral layer at the posterior part of the outer surface, that the latter layer dips here into the digital fossa (Fig. 300) and again leaves the gland at the back part of the inner surface (Fig. 300) to become once more the parietal layer. The upward extension of the serous membrane upon the lower part of the spermatic cord is also seen (Fig. 298).

An accumulation of fluid within the tunica vaginalis is known as **hydrocele,** which, as is evident from the relations noted above, will cover the testicle in front, above and at the sides, the gland being therefore at the lower back part of the tumor. *Congenital hydrocele* is hydrocele in a tunica vaginalis with a congenitally patulous funicular process.

The testicle is now seen to consist of the *testicle proper* and the *epididymis.*

The **epididymis** (Fig. 300), made up of the convolutions of the beginning of the vas deferens or spermatic duct and the converging tubules, vasa efferentia, that unite to form it, includes the **head** or **globus major** above, the **tail** or **globus minor** below and the intervening **body.** The **efferent duct,** or **vas deferens,** should be noted as leaving the globus minor (Fig. 301) to become a constituent of the spermatic cord (p. 627). The little appendage, sometimes double, **appendix epididymidis,** or **stalked hydatid** (Fig. 300), is of clinical as well as morphological interest, since it sometimes becomes enlarged to form a cyst. The entrance of

blood-vessels into the epididymis, branches of the spermatic and deferential arteries, should be noted (Fig. 301). It will be seen to be covered with the visceral layer of the tunica vaginalis except behind, where it is in contact with the spermatic cord, and the front surfaces of the head and tail.

The form of the epididymis and its relation to the testicle proper account for the shape and situation of the swelling characteristic of its inflammation, **epididymitis.** The continuity of its tube with the vas deferens and of the latter with the ejaculatory duct and urethra explain the production of epididymitis by extension of urethral infections, usually gonorrhœal.

The testicle proper is seen to be enclosed within a dense sheath, the **tunica albuginea.** The **appendix testis** or **unstalked** or **sessile hydatid** (Fig. 301) may be found near the upper pole of the gland.

Fig. 301.—Right testicle, medial surface, from the same subject as Fig. 300.

The relation of the epididymis to the posterior aspect of the testicle has been seen, as have also the relations of the tunica vaginalis.

After the study of the spermatic cord *in situ* and its removal from the body, which is the next stage of the work (p. 627), the testicle should be further studied with the view of obtaining information as to its internal structure.

Having placed the testis and cord in water in a cork-lined tray or, if the latter be not available, on several layers of damp gauze after some minutes' immersion in water, and having fixed the preparation with push-pins upon the bottom of the tray or board, as the case may be, the body and tail of the epididymis may be cautiously separated from the testis, noting the close connection between it and the globus major by means of the vasa efferentia.

Making a transverse section through the testis at about its middle, the tunica albuginea is seen to be not only an enveloping sheath but to be prolonged into the interior of the gland from a thickening of the albuginea, the **mediastinum testis** or **body of Highmore,** which extends along its posterior border. From the mediastinum, what appear as fibrous bands in the section are seen to radiate, these apparent bands being the cut surfaces of septa that diverge from the mediastinum in such manner as to divide the testis into imperfectly separated compartments. The branches of the spermatic artery may be traced to their points of entrance into the mediastinum which they perforate on their way to the interior of the gland, where they follow the septa and also spread out upon the deep surface of the albuginea, forming a vascular layer, the **tunica vasculosa** or **pia mater testis.** The vasa efferentia have already been noted as emerging from the upper part of the mediastinum to reach the globus major (Fig. 302).

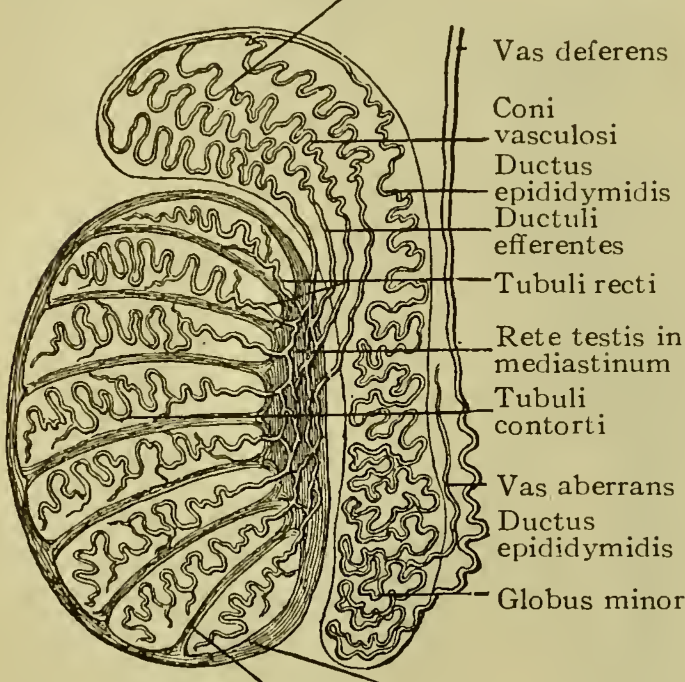

FIG. 302.—Diagram showing relations of secretory tubules and system of ducts.

Each compartment of the testicle is seen, when examined with a lens, to contain a convoluted tube or tubes, the **tubuli seminiferi,** of which one, two or three are to be found in a single compartment, held together by delicate connective tissue, and the epithelial lining of which stands in direct relation to the development of the spermatozoa. An attempt should be made to unravel some of the seminiferous tubules under water; if successful—it is apt to be only partially so—the tubule will be found to have a length of from ten to twenty-five inches.

As they approach the mediastinum, several tubules unite, forming a straight tubule, the series of **straight tubules, vasa recta,** entering the mediastinum and intercommunicating to form a network, the **rete testis.** Examining the cross section of the mediastinum with a lens, minute apertures may be detected, the cut tubules of the rete. The rete extends throughout almost the entire length of the mediastinum and terminates above in the vasa efferentia noted previously as entering the epididymis.

The **structure of the epididymis** should now be investigated by cautiously separating the head from the testis to note the fifteen to twenty efferent ducts, tubuli efferentes or vasa efferentia continued from the rete. If carefully pulled apart, these ducts may be traced, if not indi-

vidually, *en masse*, to their coiled terminations, the pyramidal masses or **coni vasculosi.** The latter and the coiled beginning of the **tube of the epididymis** which results from the union of the ducts of the vascular cones, make up the globus major of the epididymis. If the dissector has patience and skill he may demonstrate that the body and globus minor are made up of the remainder of the tube of the epididymis so tortuously coiled that when unravelled it has a length of eighteen to twenty feet.

The **tube of the epididymis** at the lower limit of the globus minor becomes the **vas deferens** or **spermatic duct,** which has already been traced through the spermatic cord.

The denseness and unyielding character of the tunica albuginea render **orchitis,** inflammation of the testis, an exquisitely painful affection. Orchitis results commonly from gonorrhœal infection, but also from mumps and scarlet and typhoid fevers. A wound of the albuginea permits the protrusion of the seminiferous tubules, **hernia testis.**

The descent of the testis (p. 623) may not occur. One testicle may be retained in the abdomen, **monorchism,** or both may fail to descend, **cryptorchism.** An undescended testis may begin its descent at any period of life and is quite apt to become pinched in the inguinal canal; in a case seen by the writer, this occurred in a married man of thirty who had never noticed any deficiency of sexual power. Rest in the recumbent posture, the local application of cold and gentle manipulation sufficed to bring the gland from the canal into the scrotum.

The **blood=supply** of the testis is the spermatic artery (a. testicularis) from the abdominal aorta. The epididymis also receives branches from the cremasteric and deferential arteries. The **veins** correspond with the arteries; the writer has found the cremasteric and deferential veins very greatly enlarged in cases of varicocele. The **lymphatics** go to the lumbar lymph-nodes.

The **nerves** of the testicle are from the aortic and renal plexuses through the spermatic plexus which accompanies the spermatic artery, the spinal fibres reaching the renal and solar plexuses through the splanchnics from the lower intercostal nerves.

The Spermatic Cord.—The spermatic cord has been seen to traverse the inguinal canal and to pass into the scrotum to become connected with the posterior aspect of the testicle. Its **coverings** have been dissected (p. 621). Its **constituent parts** are now to be examined. Its chief bulk is seen to consist of the *spermatic veins*, while less conspicuous but more important structures are the *spermatic duct* and its *artery*, the *spermatic artery*, the *nerves* and the *lymph-vessels*.

The **vas deferens** or **spermatic duct** (Fig. 300) may be recognized in life as a wire-like cord on the posterior surface of the spermatic cord. This should be isolated at the lower pole of the testicle where it begins as the continuation of the tube of the epididymis and traced upward through the inguinal canal to the internal abdominal ring, being separated from the other parts of the cord sufficiently for recognition.

From the internal ring, where the structures of the cord are dissociated or assembled according to the direction in which one follows them, the duct should be traced inward across the deep epigastric artery, then over the external iliac artery and vein (Fig. 300) and downward along the lateral wall of the pelvis to the side of the bladder. Its *termination* has been seen (p. 573).

The **artery of the vas deferens** (a. deferentialis) arising from the superior vesical or from the hypogastric axis (Fig. 333) as the vesiculo-deferential artery, is seen in close relation with the vas (Fig. 300) and should be traced to the upper part of the testicle.

The **spermatic artery** (a. testicularis) cannot at this stage be traced from its **origin** in the abdominal aorta (Fig. 326), but should be followed from the internal ring through the canal and downward along the cord (Fig. 300) to the testicle (p. 625). It is accompanied by the spermatic plexus of nerves (p. 627). To isolate this and the other structures of the cord, the latter may be removed from the body by cutting it at the internal ring to dissect it under water, but there is a distinct advantage in dissecting it *in situ*—supported on a board (p. 621)—as the relations of the parts are thus preserved. If removed at all, this should not be done until the structures noted below have been recognized and their relationships established.

The **spermatic veins** form an intricate plexus, the **spermatic** or **pampiniform plexus** (Fig. 300), which begins at the back of the testicle and passing upward converges to a less number of branches until finally a single vein is formed. Tracing this from the internal ring, it will be seen to pass beneath the parietal peritoneum of the iliac fossa and therefore behind the viscera. After the removal of the latter, the **right vein** will be seen to *terminate* in the inferior vena cava, while the **left,** passing behind the sigmoid colon, *ends* in the left renal vein.

The spermatic venous plexus is peculiarly liable to varicosity, *i.e.*, dilatation and elongation of its trunks, forming a swollen mass in the scrotum called **varicocele.** This liability to dilatation depends upon the lack of support by the lax walls of the scrotum, the influence of gravity, the absence of valves and the pressure to which the veins are subjected in the inguinal canal and in the abdominal cavity. The greater frequency of varicocele on the left side is thought to be due to the longer course of the left vein, since the left testicle is lower than the right, the relation to the sigmoid colon and the entrance of the left vein into the renal vein at a right angle.

A smaller venous plexus will be noted in relation with the vas deferens, these veins corresponding to the artery of the vas.

The **cremasteric artery** (a. spermatica externa) should be traced from its origin in the deep epigastric (Fig. 300).

The **genital branch** (n. spermaticus externus) of the *genito-crural nerve* may be found at its entrance into the inguinal canal near the internal ring (Fig. 297) and followed along the deep aspect of the cord to its *distribution* to the cremaster and the skin of the scrotum.

THE ABDOMINAL CAVITY.

The **boundaries** of the abdominal cavity are, *above*, the vault of the diaphragm; *posteriorly*, the lumbar and sacral vertebræ, the psoas and quadratus lumborum muscles and the lumbar aponeurosis; *laterally* and *ventrally*, the flat muscles and aponeurosis already considered, while the *floor* is constituted by the iliac fossæ and the structures forming the floor of the pelvis, which latter will be considered in connection with that cavity.

The **regions of the abdomen** are arbitrary divisions for the sake of convenience in study. Many different methods of subdividing the cavity have been employed. A convenient method is to draw a horizontal line between the lowest points of the costal margins, approximately the tenth costal cartilages, and another line between the highest points of the crests of the ilia, the planes corresponding to these lines dividing the cavity into a *superior* or *epigastric*, a *middle* or *umbilical*, and a *lower* or *iliac* or *hypogastric zone*. These zones are subdivided into three each by two vertical planes corresponding with lines prolonged upward from the ilio-pectineal eminences. The nine regions thus defined are respectively, in the upper zone, the right and left *hypochondriac* and the *epigastric regions*, in the middle zone the *right* and *left lumbar* and the *umbilical regions*, in the lower zone the *right* and *left iliac* and the *hypogastric region*.

The relation of the transversalis fascia, one of the **lining fasciæ** of the abdomen, has been considered. The other fasciæ lining the cavity, that is, the *lumbar fascia*, the *iliac fascia* and the *pelvic fascia*, will be taken up as they are met with in the course of the dissection. Before proceeding to the dissection of the contents of the abdomen it is necessary to take note of the general arrangement of the viscera and of their relation to the peritoneum.

The Peritoneum.—The peritoneum, like other serous membranes, consists of a *visceral layer* applied closely to the surfaces of certain of the viscera and a *parietal layer* applied to the inner face of the abdominal wall, these two being continuous with each other so as to form an absolutely closed sac. A viscus or organ may have a partial investment of peritoneum or a complete investment, this depending upon the closeness of the relation of the organ in question to the abdominal wall; for example, organs which maintain a close relation with the wall of the abdomen and are not intended to move about will be only partially clothed with peritoneum, while those which are intended to move freely and which do not remain in contact with the abdominal wall receive a complete investment. Such freely movable organs, being clothed with *visceral peritoneum* which is continuous with the *parietal peritoneum*, are necessarily connected with the abdominal wall by folds of this mem-

brane indicating the places of reflection of the peritoneum from the wall to the organ and back again. Such folds in the case of hollow viscera are usually designated *mesenteries*, while in the case of solid viscera they are often designated *ligaments*. As an aid to the comprehension of the arrangement of the peritoneum one may conceive of the abdominal cavity as being quite large in proportion to the space occupied by the contained viscera and think of the viscera as being arranged at various places in contact with the walls of this cavity. If now the peritoneum, as an absolutely closed bag, be conceived as being placed within this cavity and of expanding so as to cover every part of its exposed wall as well as those surfaces of the viscera which are not in contact with the wall, and then think of some of these viscera as gradually moving away from the wall and carrying with them as they move the peritoneum which covers them, the student will understand that such viscera will thus acquire a complete investment of that membrane and will acquire, also, *mesenteries* or *ligaments* in the form of folds by which the peritoneum covering them is continuous with that which still remains in contact with the wall.

A **sagittal section of the abdominal cavity** (Fig. 303) should be examined and the course of the peritoneum in such a section traced, beginning at the umbilicus and passing upward to the diaphragm and then backward to a point corresponding with the upper border of the posterior surface of the liver. At this point the peritoneum leaves the wall and passes to the posterior surface of the liver as the *upper layer* of the **coronary ligament** of that organ and now becomes visceral peritoneum. Following along the upper surface of the liver to its anterior border and then to the under surface, and passing backward to the anterior lip of the transverse fissure, it again leaves the liver to pass down to the lesser curvature of the stomach, thus forming the *anterior layer* of the **gastro-hepatic** or **lesser omentum.** Again becoming visceral peritoneum it covers the anterior surface of the stomach until it reaches its greater curvature, from which it passes downward in front of the coils of the small intestine and the transverse colon, and returning to the under surface of the transverse colon forms an apron-like fold, the **great omentum.** Investing the under surface of the colon, again as visceral peritoneum, it leaves this part of the intestinal tube to go to the posterior abdominal wall, forming the *lower layer* of the **transverse mesocolon.** Now again parietal peritoneum, it passes downward along the posterior abdominal wall and in the neighborhood of the second lumbar vertebra it leaves the wall to form the *right* or *upper layer* of the **mesentery** of the jejunum and ileum, which parts of the small intestine it completely invests, returning to the line of reflection and thus completing the mesentery. Continuing down the posterior abdominal wall into the pelvic cavity it invests the upper part of the anterior surface of the rectum and

then is reflected to the lower part of the posterior surface of the uterus in the female, forming thus the **recto-uterine fold** or **fold of Douglas.** Passing upward over the posterior surface of the uterus and then downward on its anterior surface, but not to its lower extremity, it is reflected to the posterior surface of the bladder, forming the **vesico-uterine fold.**

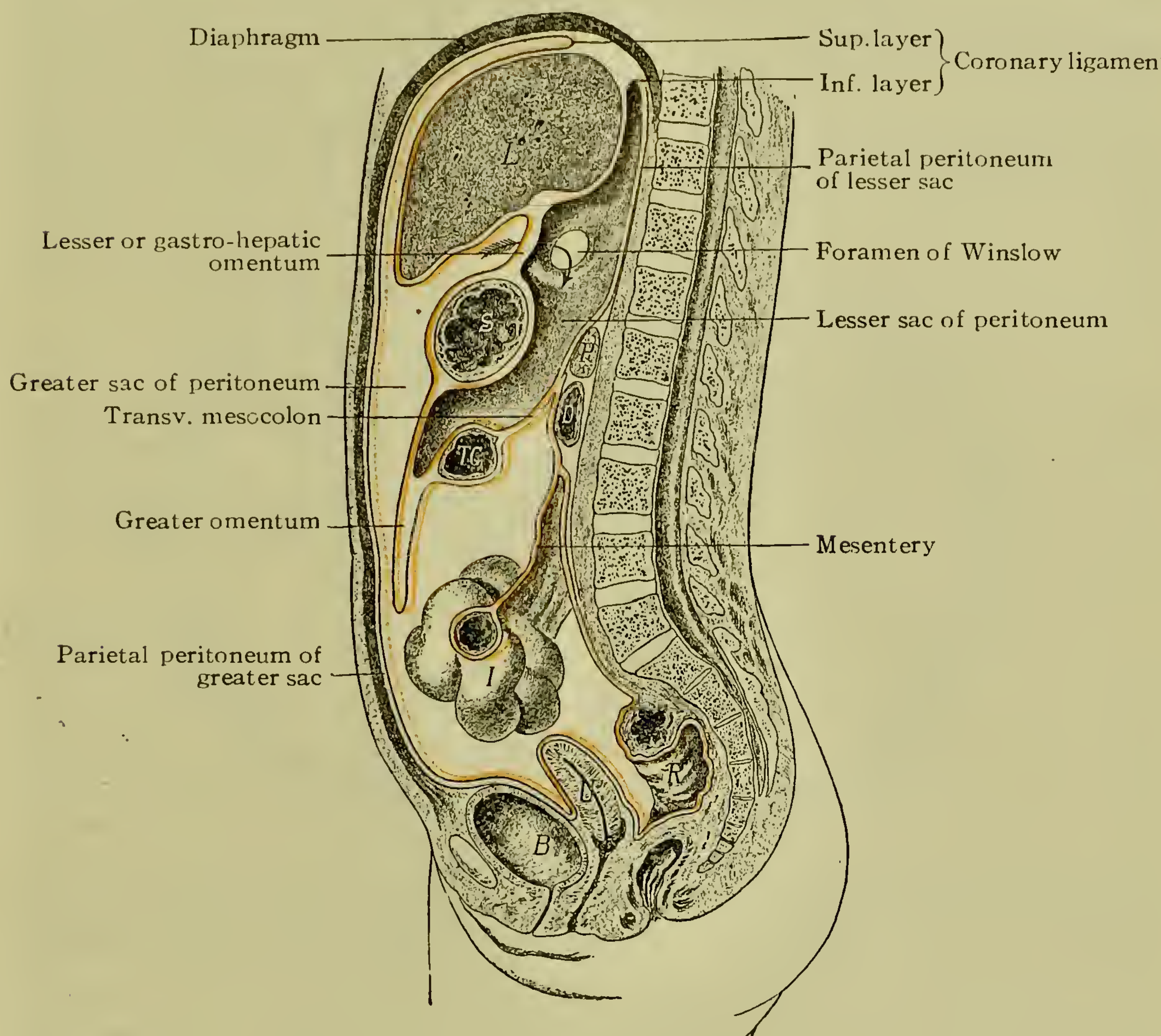

FIG. 303.—Diagram of sagittal section of abdomen showing arrangement of peritoneum; arrow passes from greater into lesser sac through foramen of Winslow; *L*, liver; *S*, stomach; *TC*, transverse colon; *I*, small intestine; *D*, duodenum, transverse part; *P*, pancreas; *B*, bladder; *U*, uterus; *R*, rectum.

Passing upward to the summit of the bladder it follows the urachus to the anterior abdominal wall, becoming again parietal peritoneum, and continues up to the umbilicus, the point of starting.

The peritoneum as thus traced presents no break in its continuity, but the student will have noticed that some parts of the abdominal wall as well as some of the viscera were not accounted for. The part traced is known as the **greater sac** of the peritoneum in contradistinction to

the **lesser sac,** which will now be followed. Beginning at the posterior abdominal wall opposite the lower border of the liver, the parietal peritoneum of the lesser sac leaves the wall and passes to the lower part of the posterior surface of the liver, forming thus the *lower layer* of the **coronary ligament** of that organ. Passing from the posterior surface of the liver to its under surface it leaves the liver at the posterior lip of the transverse fissure to reach the lesser curvature of the stomach, thus forming the *posterior layer* of the **lesser** or **gastro=hepatic omentum.** Continuing now as visceral peritoneum it covers the posterior surface of the stomach as far as its greater curvature, where it leaves the stomach to follow the similar layer of the greater sac and assist in the formation of the **great omentum.** As it returns to the transverse colon it passes to its anterior and upper surfaces and then back to the abdominal wall as the *upper layer* of the **transverse mesocolon** and now continues, as parietal peritoneum, upward to the point of starting.

In such a sagittal section the greater and lesser peritoneal sacs appear to be absolutely separate. The two sacs are continuous with each other, however, by a constricted passage-way, the foramen of Winslow, situated behind the right border of the lesser omentum. This will be better understood when a transverse section of the abdomen at the level of the stomach is examined.

The **transverse section of the abdomen** below the level of the stomach (Fig. 304) should now be studied. Beginning with the parietal peritoneum at the umbilicus and passing to the right and around the lateral wall of the abdomen to the position of the ascending colon, the peritoneum here leaves the wall to invest the outer surface, the anterior surface and the inner surface of the ascending colon, after which it returns to the posterior abdominal wall. Continuing to the left it passes over the front of the ascending cava and abdominal aorta, and follows the abdominal wall to the left to the position of the descending colon, when it leaves the wall to invest the inner, the anterior and the outer surfaces of the colon, after which it returns to the abdominal wall. A variation of this plan is frequently seen consisting in the fact that the descending colon is completely invested, its posterior surface then being connected by the *descending mesocolon* with the posterior abdominal wall. Continuing as the parietal peritoneum around the left lateral wall to the anterior wall it becomes continuous at the mid-line with the layer of parietal peritoneum with which we began.

A transverse section of the abdomen at the level of the stomach (Fig. 305) shows a considerably more complicated arrangement. Beginning at the mid-line anteriorly to trace the parietal peritoneum, it is followed as in the last case to the right of the posterior wall, where it passes over the anterior surface of the right kidney, over the vena cava and aorta and upon the anterior surface of the left kidney, from which it

is reflected to the hilum of the spleen, thus forming one layer of the **lieno=renal ligament.** Leaving the spleen almost immediately it passes to the cardiac end of the stomach, forming thus one layer of the **gastro=splenic omentum.** Continuing over the posterior surface of the stomach and from the pyloric end of the stomach to the posterior surfaces of the beginning of the duodenum and of the portal vein, hepatic artery and hepatic duct, it passes around the right side of these three vessels to the anterior surface of the beginning of the duodenum to reach the anterior surface of the stomach. Passing to the left extremity of the stomach, it goes to the hilum of the spleen, completing thus the **gastro=splenic omentum.** From the hilum of the spleen it passes forward over its an-

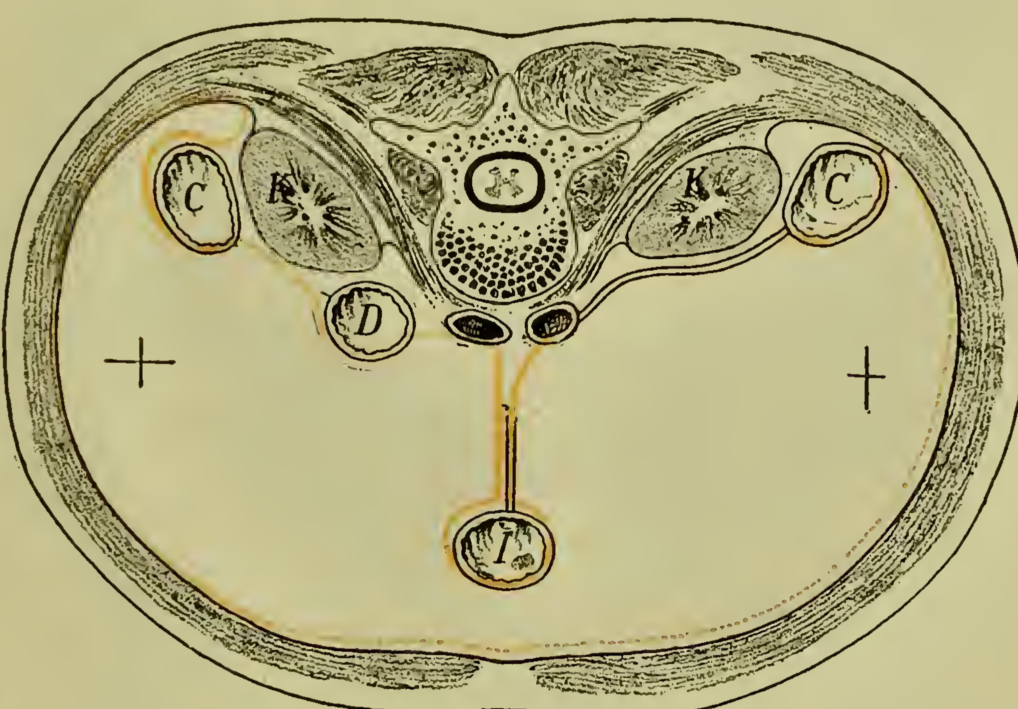

FIG. 304.—Diagram of cross section of abdomen below level of stomach showing parietal (broken blue line) and visceral peritoneum (continuous blue line) ; *C*, *C*, ascending and descending colon ; *I*, small intestine ; *D*, duodenum, descending part ; *K*, *K*, kidneys.

terior surface and around its anterior border, and, investing the convex surface, reaches its inner or renal surface, from the anterior part of which it is reflected to the left kidney, completing the **lieno=renal ligament.** Leaving the kidney it passes to the left part of the posterior abdominal wall, which it follows to the lateral and then to the anterior wall to the point of starting.

In studying such a section, it should be remembered that the layers of peritoneum on the anterior and posterior surfaces of the stomach are continuous respectively in the upward direction with the anterior and posterior layers of the lesser omentum, and downward with the two layers which were seen in the sagittal section to be reflected from the greater curvature of the stomach to form the great omentum. It should also be noted that the space enclosed by the peritoneum is encroached

upon by the stomach, the hepatic artery, the portal vein and the hepatic duct in such manner as to divide it into a larger space, the greater peritoneal sac, and a smaller, the lesser sac, situated behind the stomach and the lesser omentum; and that these two sacs communicate with each other through a constricted passage-way situated behind the right free border of the lesser omentum which is known as the **foramen of Winslow.**

The dissector cannot be too strongly urged to trace carefully the peritoneum as here outlined that he may have a better understanding of the relations of this membrane to the viscera which he will encounter in his dissection of the abdominal cavity.

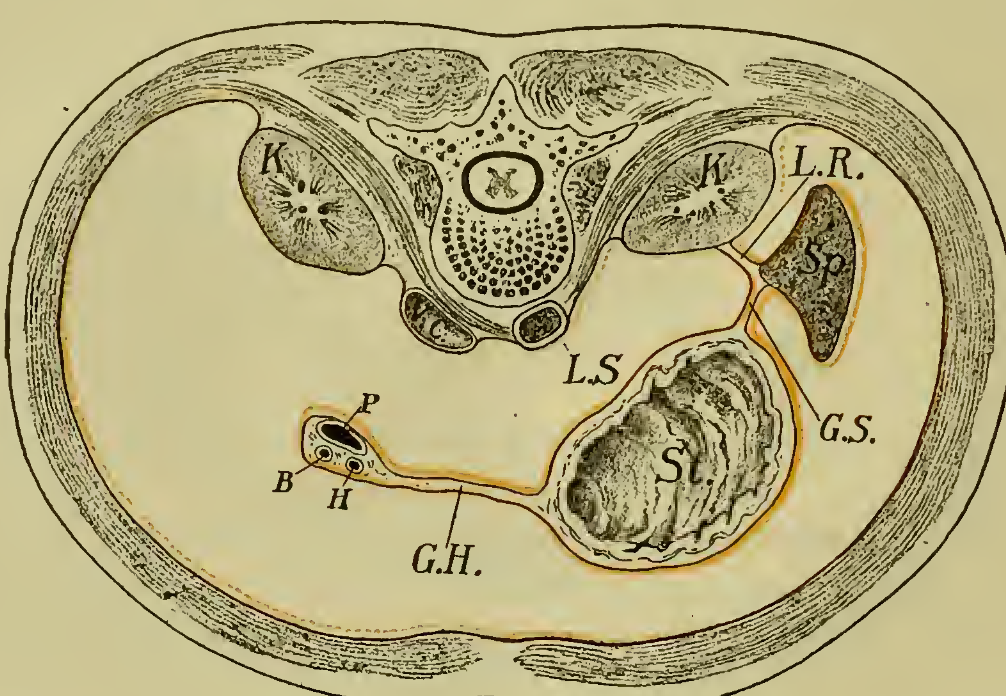

FIG. 305.—Diagram of cross section of abdomen through level of foramen of Winslow, showing parietal and visceral peritoneum; *L.S.*, lesser peritoneal sac; *G.H.*, gastro-hepatic omentum containing portal vein (*P.*), hepatic artery (*H.*) and bile-duct (*B.*), which lie in front of the foramen of Winslow; *St.*, stomach; *Sp.*, spleen; *V.C.*, vena cava inferior; *A.*, aorta; *G.S.*, gastro-splenic omentum; *L.R.*, lieno-renal omentum.

THE LIVER.—Making a longitudinal incision about one fourth of an inch to the left of the mid-line from the umbilicus to the ensiform cartilage, the upper half of the abdominal wall should be reflected. The **falciform** or **suspensory ligament** of the liver (Figs. 307 and 316) will be found attached to the deep surface of the right flap. The **round ligament** of the liver, the impervious remnant of the obliterated umbilical vein, may be felt as a thickening within the free border of the falciform ligament. The umbilical vein of the fetus, entering the body at the umbilicus, passes to the anterior part of the inferior surface of the liver, and as the liver, during fetal growth, gradually recedes to the upper part of the abdomen, the vein is made to diverge somewhat from the anterior abdominal wall, carrying with it the parietal peritoneum, which thus

becomes drawn out to form the falciform ligament. The dissector should trace, by palpation with the fingers, the round ligament to the under surface of the liver. The falciform ligament represents that part of the ventral mesentery of fetal life which at the beginning of the development of the liver is situated above the site of the prehepaticus or liver-ridge. If now the falciform ligament be traced it will be seen to

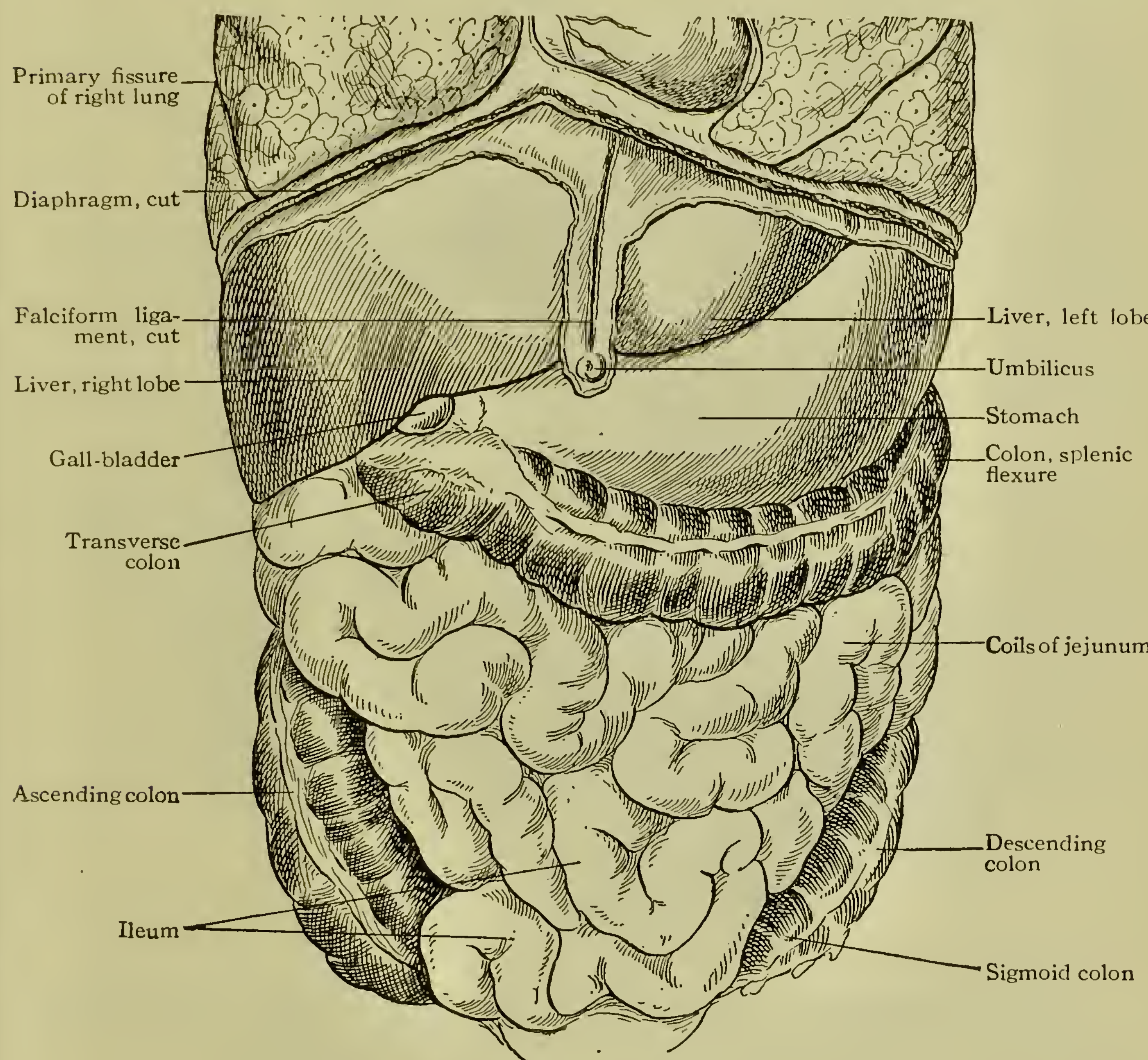

FIG. 306.—Abdominal viscera, anterior view. (His model.)

be attached to the liver along the mid-line of its upper surface, along which line these two layers are reflected from the liver to the under surface of the diaphragm.

The **upper layer of the coronary ligament** of the liver (Fig. 303) may be demonstrated by depressing the organ slightly and passing the hand along its convex surface to the posterior limit of the latter, when the upper layer of the coronary ligament may be felt as a fold passing from

the liver to the posterior abdominal wall. The **lateral** or **triangular ligaments** may be demonstrated similarly by passing the hand from the convex surface of the organ first to the right abdominal wall and then to the left part of the under surface of the diaphragm, when it will be seen that the peritoneum on the convex surface is reflected laterally to these respective regions (Fig. 307).

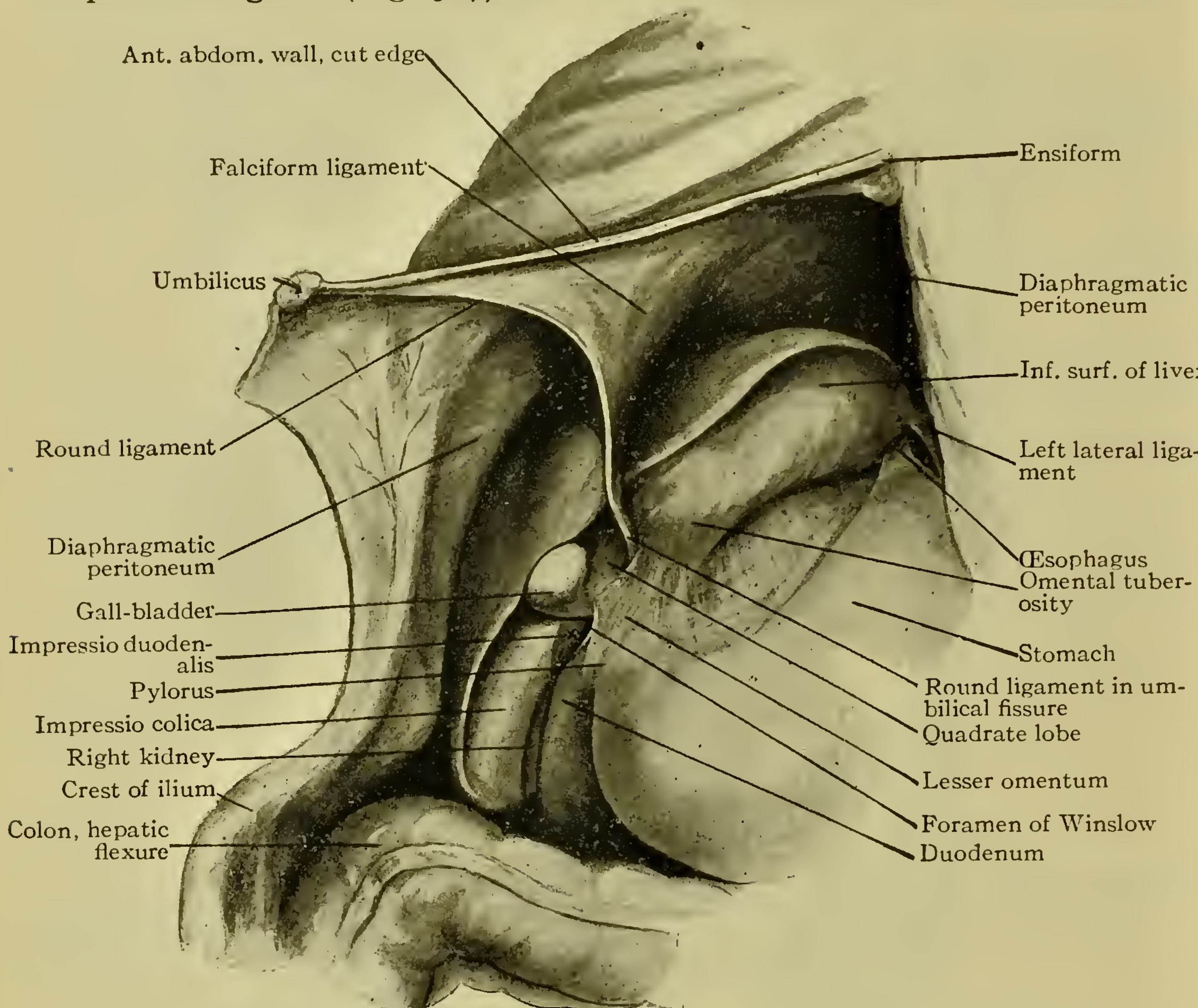

Fig. 307.—The liver and its falciform and round ligaments viewed from in front and the left.

The Under Surface of the Liver.—The anterior edge of the liver should now be fixed with a few stitches to the costal margin so as to restore the organ as nearly as possible to its normal position.

The **position** of the liver in the right hypochondrium, the epigastrium and, to a slight extent, in the left hypochondrium, corresponds *posteriorly* with the tenth and eleventh thoracic vertebræ; *laterally*, in the mid-axillary line, to the seventh to the eleventh ribs; and *anteriorly*, in the mid-clavicular line, to the area from the fifth rib to the costal margin. The border of the right lobe, it will be seen, crosses the subcostal angle in a line from the ninth right costal cartilage to the seventh left, terminating about one inch and a half to the left of the sternum.

THE GALL-BLADDER.—The gall-bladder appears at the anterior part of the under surface of the liver corresponding to a point on the abdominal wall at the ninth costal cartilage to the right of the rectus muscle, its position necessarily depending upon its degree of distention. Following the gall-bladder with the fingers, it will be observed to diminish from the *fundus* to the *neck*, backward and to the left, where it merges

FIG. 308.—Anterior view of stomach, transverse colon and gall-bladder, showing branches of cœliac axis, corresponding veins and nerves.

into the **cystic duct.** The gall-bladder usually lies within the *fissure for the gall-bladder* on the under surface of the liver, the peritoneum which invests the under surface of the liver passing directly over the gall-bladder; this relation may be modified in such manner that the gall-bladder receives a complete peritoneal investment and has a small mesentery.

From this relation of the gall-bladder to the peritoneum it is evident that **rupture** of the gall-bladder will result in intraperitoneal extravasation of its contents with resulting *peritonitis*. An accumulation of **gall-stones** in the gall-bladder may be detected by palpation of the anterior abdominal wall.

The lower layer of the right lateral ligament may be demonstrated by inspecting the under surface of the organ as well as by palpating it and noting that its peritoneal investment passes off laterally to the abdominal wall.

The **lesser** or **gastro-hepatic omentum** (Figs. 307 and 303) should now be studied by first pulling down the stomach and fixing it in this position, with due care to avoid perforation of its wall. The lesser omentum should be followed with the fingers to its attachment to the transverse fissure of the liver. Its right free border should be grasped between the thumb and fingers and palpated to detect the presence here of the *portal vein*, the *hepatic artery* and the *hepatic duct*, and two fingers should be passed behind this border toward the left into the **foramen of Winslow,** by which aperture the greater and lesser peritoneal sacs communicate (Fig. 305). The **boundaries** of the foramen of Winslow are, *in front*, the right free border of the lesser omentum with its contained structures; *behind*, the ascending vena cava, which should be palpated with the fingers; *above*, the caudate lobe of the liver (which is behind the transverse fissure of that organ); *below*, by the beginning of the hepatic artery and of the duodenum.

The under surface of the liver is divided into right and left portions by the attachment of the round ligament, which may be followed backward to the posterior limit of the under surface. This structure occupies the **umbilical fissure,** or that part of the **longitudinal fissure** which is found on the under surface. The **quadrate lobe** is that portion of the under surface which lies between the umbilical fissure and the fissure for the gall-bladder. The **transverse fissure** or **portal fissure,** the *porta* or gate-way of the liver, lies in the transverse axis at the posterior limit of the quadrate lobe. The structures already found in the lesser omentum —the hepatic artery, the portal vein, the hepatic duct and, as will be seen later, the lymphatics and the nerves—enter or leave the liver through this fissure. The cystic duct (Fig. 314), referred to above, will be found here curving down to unite at an acute angle with the hepatic duct.

That part of the under surface of the right lobe which is to the right of the gall-bladder presents three concavities, the more anteriorly placed one being for the accommodation of the hepatic flexure of the colon, which should be displaced slightly in order to expose this fossa or **colic impression** (Fig. 307). The **duodenal impression** for the accommodation of the curve of the duodenum where its first part merges into the second, is situated to the inner side of this and somewhat more posteriorly. The **renal impression,** for the upper part of the anterior surface of the right kidney, is behind both of these.

The under surface of the left lobe of the liver in front of the lesser omentum forms a part of the dome of the stomach chamber and comes into relation with the upper part of the anterior surface of the stomach.

The lesser omentum may now be dissected, beginning at the lesser curvature of the stomach near the right free border of the omentum. The anterior layer should be carefully raised to expose the portal vein, the hepatic artery and the hepatic duct. The posterior layer of the omentum may now be torn through and partially removed.

The **hepatic artery** should now be dissected (Fig. 308). The *hepatic plexus of nerves*, evident as interlacing, rather closely adherent white bands upon the surface of the artery, more or less completely investing it, is derived from the solar plexus and from the left pneumogastric nerve on the anterior surface of the stomach. Enough of these fibres should be isolated for demonstration. The artery should now be followed downward and then to the left to its **origin** from the cœliac axis. It is this first part of the artery which comes into relation with the inferior boundary of the foramen of Winslow. The **branches** are, first, the *pyloric branch*, which should be traced to the pyloric end of the stomach; the *gastro-duodenal* artery, which should be traced in its course downward behind the pyloric end of the stomach but which cannot be completely followed at this stage; it divides into the *right gastro-epiploic* and the *superior pancreatico-duodenal* (Fig. 318). Traced upward, the hepatic artery gives origin to the *cystic*, which should be traced to the neck of the gall-bladder, and then divides into its *right* and *left* trunks which enter the portal fissure of the liver. The **relations** of the hepatic artery brought out by this dissection should be noted; the relation of the beginning of the vessel to the lower boundary of the foramen of Winslow as well as of the major portion of it to the anterior boundary of that foramen have been noted. The hepatic duct is situated upon its right side and the portal vein behind it.

The Hepatic Duct.—The hepatic duct, the efferent duct of the liver, arises by the confluence of the *right* and *left hepatic ducts* which emerge through the portal fissure; after attaining the length of one inch and a half the hepatic duct is joined by the **cystic duct,** also having a length of one inch and a half and which should now be isolated. The union of the cystic and hepatic ducts forms the **common bile duct,** or the **ductus communis choledocus,** which has a length of about three inches. The common duct, followed downward, will be seen to pass behind the beginning of the duodenum and then to gain a position between the second or descending part of the duodenum and the head of the pancreas (Fig. 321); the latter part of its course, however, cannot be traced at this time. It terminates by piercing the inner wall of the second part of the duodenum at about four inches from the pylorus. It is usually joined at its termination by the duct of the pancreas.

The method of palpating the bile duct by introducing the finger through the foramen of Winslow has been noted above; this procedure, applicable during the course of an abdominal operation, will reveal the presence in the duct of a biliary concretion. A lymph-node near the lower part of the duct, in close relation with it, may give a wrong impression as to the presence of a gall-stone.

The Portal Vein.—The portal vein should be exposed by displacing the hepatic duct and the hepatic artery. Very much larger in calibre than either of these structures, it has a *length* of about four inches, its *origin* being the union of the superior mesenteric vein and the splenic vein near the upper border of the right extremity of the pancreas (Fig. 308). Passing upward between the two folds of the lesser omentum, it enters the portal fissure of the liver and, after repeated branchings, finally terminates in a system of capillaries. This vein and its *tributaries* drain practically the entire extent of the alimentary canal, and constitute the *portal venous system.* The portal system stands somewhat apart in the fact that, although its blood is venous blood, it is laden with certain of the products of digestion which are conveyed to the liver for elaboration. This system forms several communications with the general venous system, notably in the hemorrhoidal plexus, which is drained partly by the portal system and partly by the general venous system, since the superior hemorrhoidal vein, emptying into the inferior mesenteric vein, is a portal tributary, while the middle and inferior hemorrhoidal veins drain respectively into the internal iliac and the internal pudic veins. Another communication is near the cardiac orifice of the stomach where the veins accompanying the gastric vein, a part of the portal system, communicate with the phrenic and œsophageal veins, which belong to the general venous system.

The portal system of veins is the avenue for the conveyance of infection to the liver in cases of infective diseases of the alimentary tract.

Inflammation of the portal vein is known as *pylephlebitis,* one of the characteristic symptoms of which, due to the obstruction of the inflamed vein, is a rapidly developing ascites. On account of the communications between the two systems already noted, portal obstruction, as by a congested or contracted liver, is often evidenced by dilatation of the superficial veins of the abdominal wall.

The back part of the under surface of the liver presents a prominence, the **omental tuberosity,** which comes into relation with the posterior surface of the lesser omentum and with the lesser curvature of the stomach.

The relations of the under surface of the liver to other abdominal organs explain certain clinical facts, as for example the course taken by the pus of a hepatic *abscess,* which may find its way into any of these organs; conversely, pus in certain of these organs may make its way into the liver. The liver is subject to *rupture* from external injury, as by blows or partial crushing of the body, this rupture occurring more easily because of the friability of the liver substance and being attended by free hemorrhage because of the great vascularity of the organ. From the relations of the peritoneum as above indicated to the upper and lower surfaces of the liver, it is evident that rupture upon portions of these surfaces will be attended by intraperitoneal extravasations of blood.

The **posterior surface** of the liver will be studied after the removal of the organ from the body (p. 667).

The Greater Omentum.—The greater omentum, one of the first things to come into view upon opening the abdomen (Fig. 308), consists originally of four layers of peritoneum (Fig. 303) which usually coalesce so as to be inseparable. It is seen to contain a certain amount of fatty tissue as well as fairly well marked blood-vessels. If its lower extremity be gently raised, it is found to be connected not only with the greater curvature of the stomach, but with the transverse colon, a connection sufficiently explicable by reference to Fig. 303.

The omentum apparently serves an important purpose in protecting the intestines against changes in temperature and has a certain clinical importance. Thus, in a small perforating wound of the anterior abdominal wall it may pouch into the opening and close the wound either temporarily or curatively. Through inflammatory adhesions, it may cause *obstruction of the bowel.* It may protrude as a *hernia,* either alone or, more commonly, in company with a segment of bowel.

The Stomach.—The **situation** of the stomach in the epigastrium and the left hypochondrium varies necessarily with its degree of distention. In moderate distention its fundus rises to the level of the fifth left costal cartilage and its cardiac orifice to the level of the sixth left cartilage one half-inch to the left of the mid-line. The **pyloric extremity** is a little to the right of the mid-line about four inches below the end of the mesosternum; or, midway between the mid-line and the right costal margin on the *mid-epigastric line.* (The *mid-epigastric line* is a horizontal line drawn through the *mid-epigastric point,* which is midway between the umbilicus and the *sterno-ensiform point,* or a point which corresponds with the lower end of the mesosternum—Treves.) Owing to its relations with other viscera it comes into direct contact with the anterior abdominal wall throughout only a limited area, this corresponding to the **epigastric triangle,** which is bounded on the right side by the left border of the right lobe of the liver, on the left side by the eighth and ninth costal cartilages, and below by an imaginary line connecting the tenth costal cartilages. The so-called *stomach-chamber* (Fig. 316), the nest formed for the stomach by neighboring viscera, is formed below by the transverse colon and mesocolon, the concave anterior surface of the pancreas, the anterior or gastric surface of the spleen, the anterior surface of the left kidney and of the left adrenal and above by the left dome of the diaphragm and the under surface of the left lobe of the liver. To consider the matter in a different way, the *anterior surface* of the stomach, looking upward and forward, is in relation with the left lobe of the liver, part of the diaphragm and the anterior abdominal wall. The *posterior surface,* looking downward and backward, is in contact with the transverse mesocolon and to a greater or less extent with the transverse colon, the anterior surface of the pancreas, the gastric surface of the spleen, the left kidney, the left adrenal, the aorta and the left crus of the diaphragm.

The **peritoneal relations** of the stomach have been considered in tracing the peritoneum in the sagittal section (Fig. 303), and in the transverse section (Fig. 305), from which it is apparent that the stomach is completely invested with peritoneum, with the trifling exception of the narrow areas along the lesser and greater curvatures between the folds of the lesser and greater omenta respectively, and of a small triangular area on the posterior surface to the left of the œsophageal attachment.

The position of the stomach is subject to considerable variation, undue descent of the viscus, *gastroptosis*, owing to elongation of the lesser omentum, being not infrequently a part of general visceroptosis.

The **blood-vessels** of the anterior surface of the stomach must now be dissected, the stomach and intestines being first moderately inflated with air introduced through a blow-pipe or by bellows or pump (Fig. 308). Drawing the great omentum downward and fixing it in this position with hooks or pins, the vessels along the lesser curvature may be first isolated. Beginning at the left extremity of the lesser curvature, at the cardiac orifice, the **gastric artery** (a. gastrica sinistra), one of the three large branches of the cœliac axis, will be found. Tracing it first to its origin in the cœliac axis, it may then be traced along the upper border of the stomach from left to right, the various *branches* which pass downward being worked out as they are encountered and its anastomosis near the pyloric end with the pyloric branch of the hepatic noted. The **pyloric** or **gastric** branch (a. gastrica dextra) of the hepatic should be traced to its origin in the latter vessel.

The **left pneumogastric nerve** (Fig. 308), which lies in close proximity to the gastric artery, should be cared for and its various branches dissected. Some of these branches pass upward between the folds of the lesser omentum to reach the liver. The **gastric plexus of the sympathetic,** consisting of several nerve-strands intercommunicating with each other and closely following the course of the gastric artery, will be found in the dissection of that vessel.

The **right gastro-epiploic artery,** a branch of the gastro-duodenal of the hepatic, should be exposed at the pyloric end of the greater curvature as it comes from behind the pyloric end of the stomach and should be traced along the greater curvature from right to left to its anastomosis with the **left gastro-epiploic** of the splenic. The beginning of this latter artery will be isolated later. The various *branches* of these two vessels should be traced to the anterior and posterior surfaces of the stomach. To follow the latter branches, the anterior layer of the great omentum may be torn through close to the greater curvature. Each of these arteries is accompanied by a corresponding sympathetic plexus (Fig. 318).

The **vasa brevia,** small branches of the splenic artery (Fig. 318), may be exposed by drawing the stomach somewhat to the right and tearing through the anterior layer of the gastro-splenic omentum. This will also enable the dissector to complete the dissection of the gastro-epiploica sinistra, to facilitate which, the spleen should be anchored to the abdominal wall with a few pins or stitches, with care to avoid perforating the diaphragm.

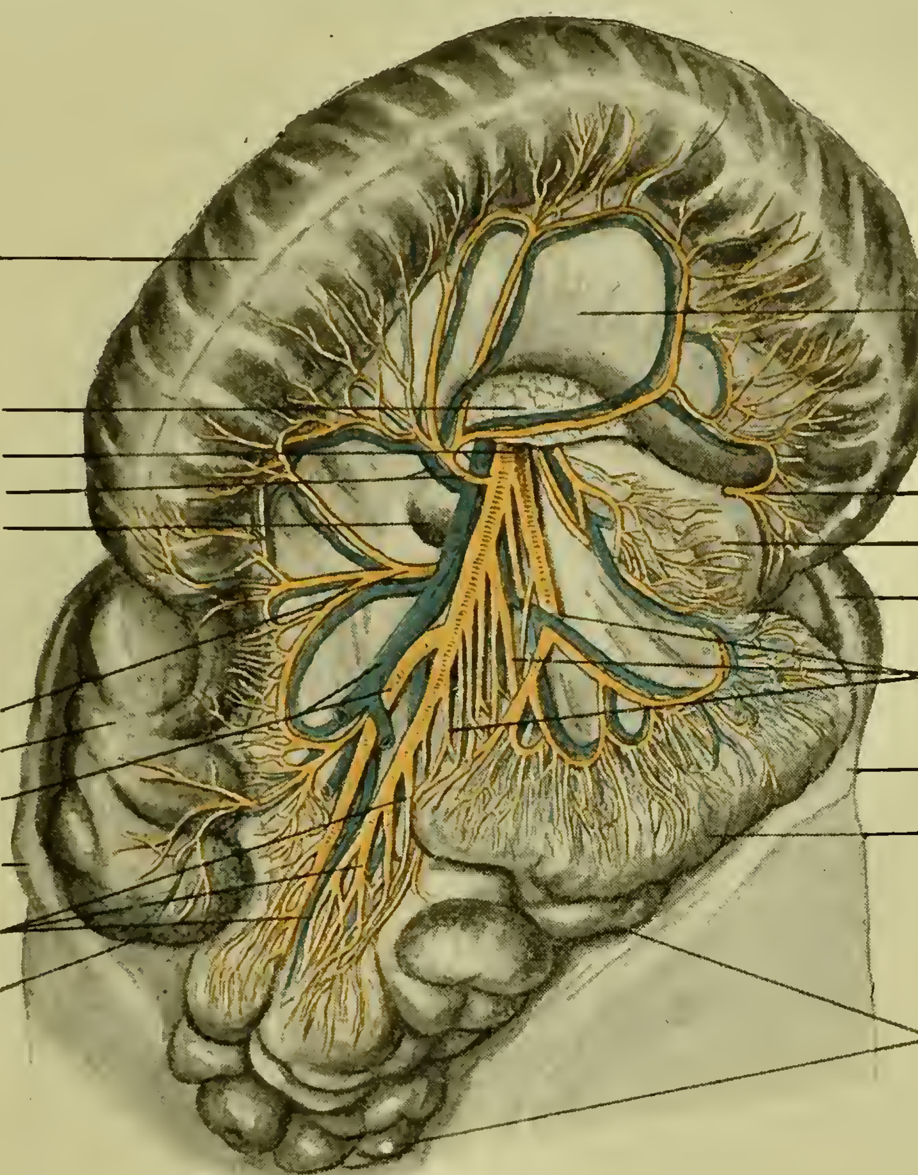

FIG. 309.—Superior mesenteric artery and vein and their branches; transverse colon and stomach have been drawn upward.

A wound of the wall of the stomach will bleed more or less freely according to its proximity to either curvature. The blood in such case will be effused into the peritoneal cavity, since the stomach is completely invested with peritoneum. Extravasation of the gastric contents—if the wound involve the entire thickness of the wall, or in case of perforation of a gastric ulcer—would likewise occur into the peritoneal cavity. Referring to Fig. 303, it will be seen that extravasation or hemorrhage from the anterior wall would take place into the greater peritoneal sac, whereas if the posterior wall be the seat of wound or rupture, extravasation takes place into the lesser peritoneal sac. In the latter case, localization of the resulting inflammation may result in the formation of a *subphrenic abscess.*

The posterior wall of the stomach and the interior of its cavity will be examined at a later stage of the work.

The blood-vessels of the anterior surface of the transverse colon may be dissected at this stage, the vessels being readily apparent through the overlying peritoneum (Fig. 308), but no attempt should be made to trace them to their origin at present.

The great omentum, the transverse colon and the greater curvature of the stomach should now be turned up over the thoracic wall and held in position with pins or hooks.

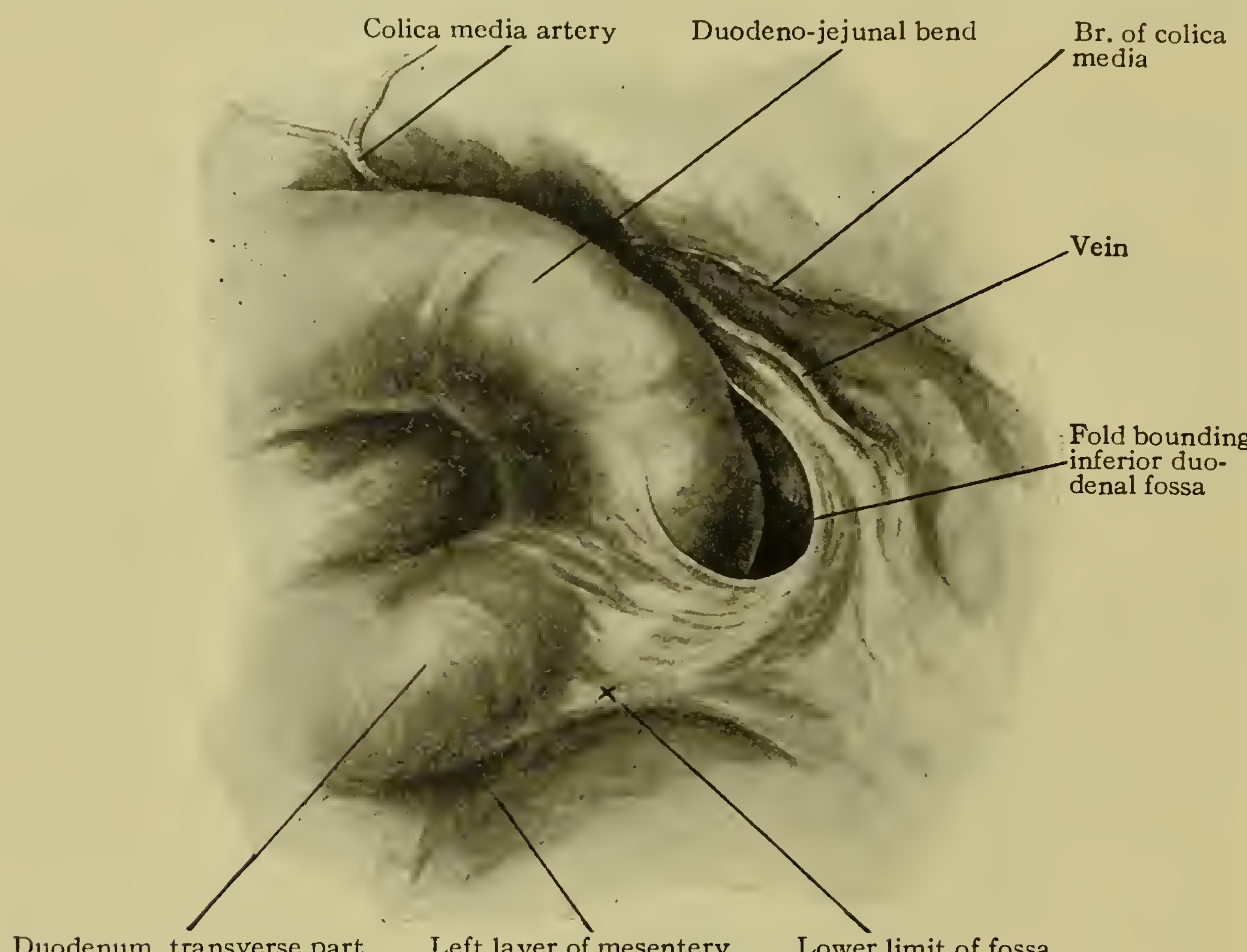

Fig. 310.—Inferior duodenal fossa.

The Small Intestine.—The first and smallest part of the small intestine, the **duodenum,** may be ignored for the present except as to its termination. The second part of the small intestine, the **jejunum,** and the third part, the **ileum,** together constituting the **jejuno=ileum,** comprising all but ten or twelve inches of the entire length (twenty-two feet) of the small intestine, are not sharply delimited from each other. One may, however, recognize a marked difference between the beginning of the jejunum and the termination of the ileum, a difference, first, as to *calibre*, the diameter of the tube diminishing markedly toward the end of the ileum; second, as to the greater degree of *vascularity* of the jejunum as compared with the lower part of the ileum; third, as to

the *greater size of the connivent valves* in the upper part of the jejunum as eompared with the size of those of the ileum. The dissector should verify these points by comparing a coil near the beginning of the jejunum with a coil near the end of the ileum, the size of the eonnivent valves being recognizable by holding the intestine up to the light.

The **peritoneal relations** of the jejunum and ileum differ markedly from those of the duodenum; the jejuno-ileum is completely invested with peritoneum, the double fold which connects these portions of the

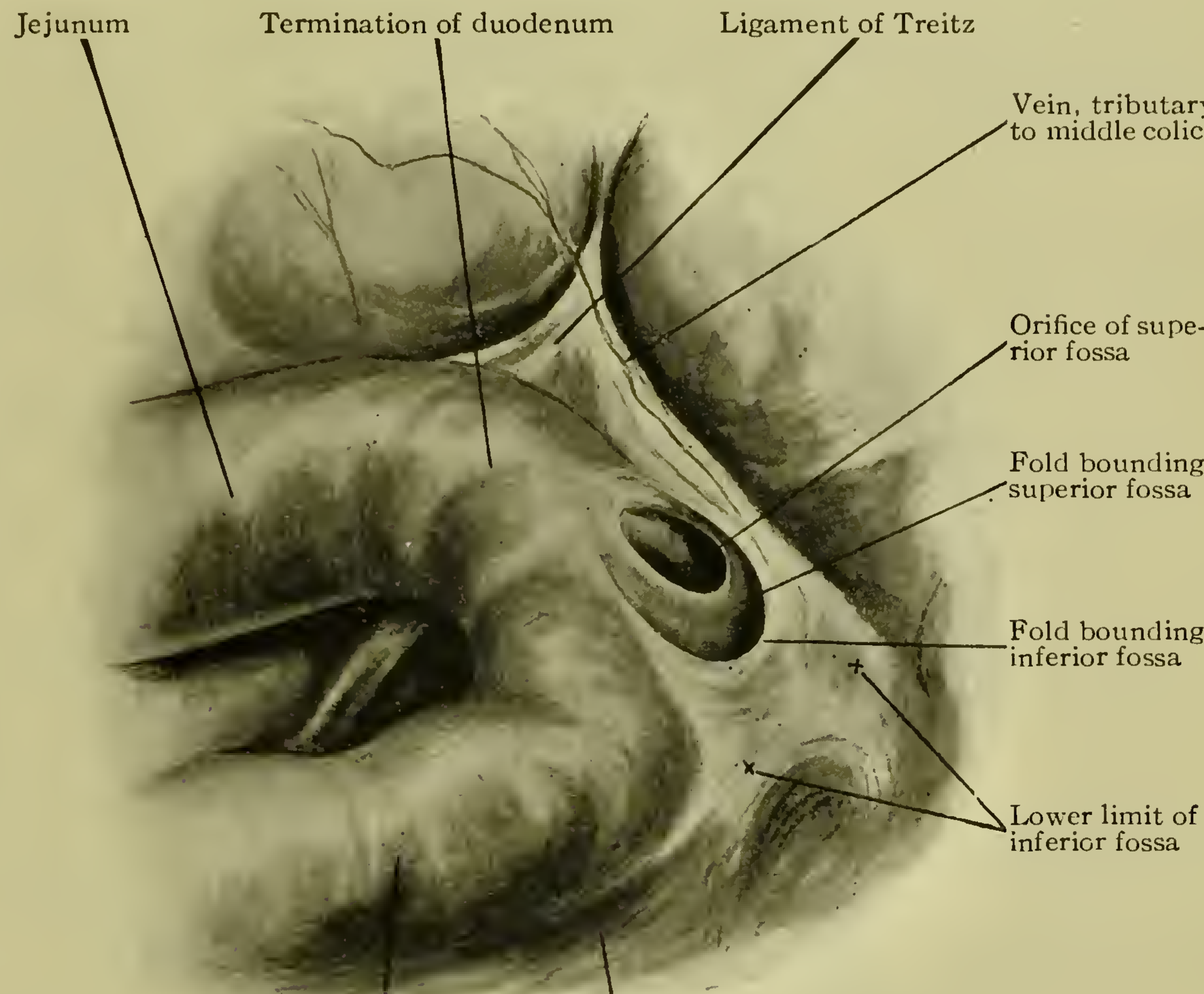

FIG. 311.—Superior and inferior duodenal fossæ.

alimentary tube with the posterior abdominal wall being the **mesentery.** If the eoils of small intestine are raised with the hands, the mesentery beeomes apparent. Displacing all of the eoils of small bowel to the right side, the left fold of the mesentery will be exposed. Its line of attachment to the posterior abdominal wall should be noted as beginning at the left side of the seeond lumbar vertebra, passing obliquely downward and to the right to terminate near the right saero-iliae junction. At the upper end of this line of attaehment the terminal portion of the duodenum is seen (Fig. 309), becoming eontinuous with the beginning of the jejunum.

The duodeno-jejunal junction is interesting as being the site of various forms of peritoneal pockets or fossæ which are important clinically.

The **inferior duodeno-jejunal fossa** (Fig. 310) is the most constant of these and is situated opposite the beginning of the fourth part of the duodenum behind a non-vascular fold of the peritoneum. The orifice of the fossa looks upward.

The **superior fossa** (Fig. 311), second in order of frequency, is situated near the level of the termination of the fourth part of the duodenum

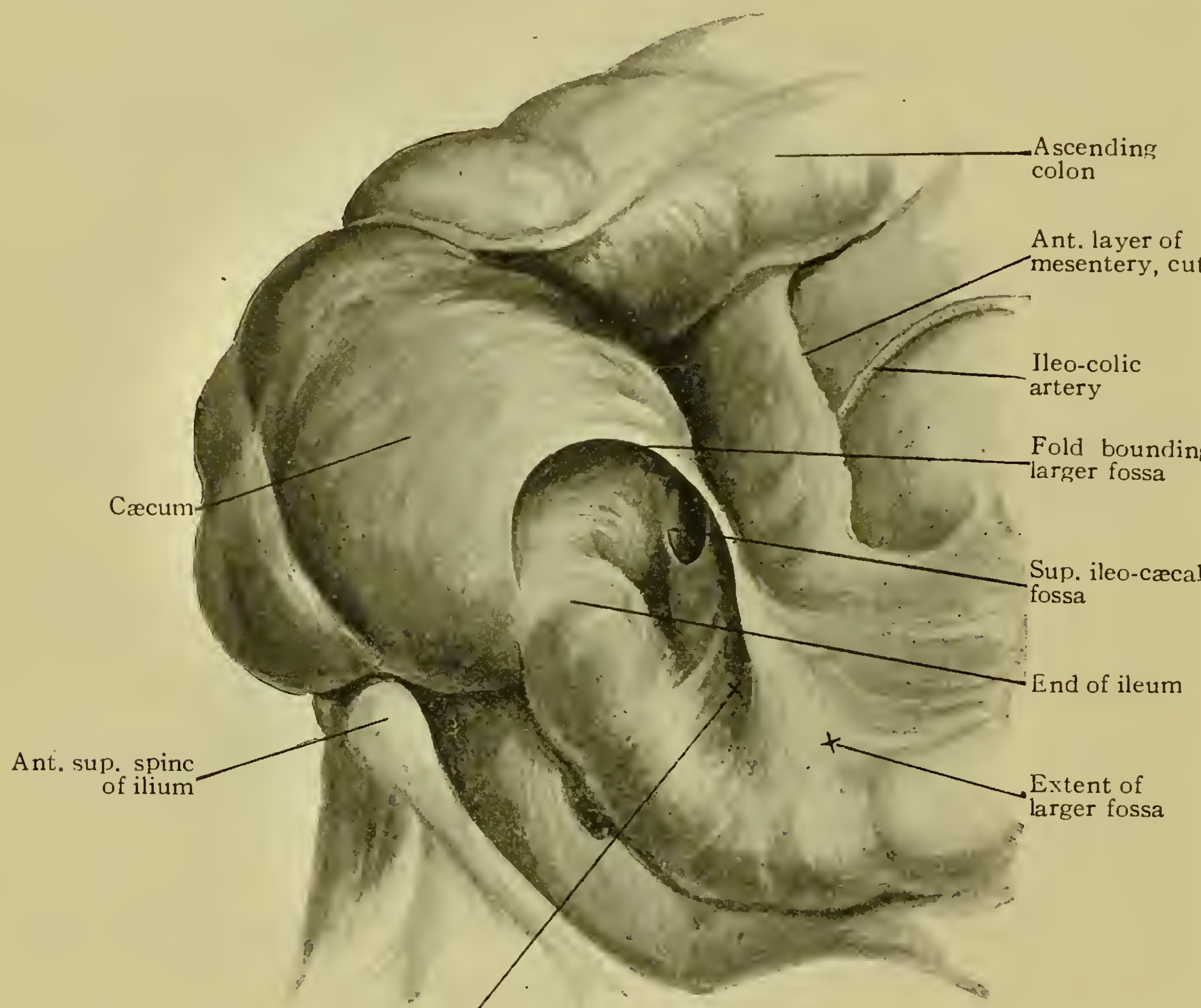

FIG. 312.—Superior ileo-cæcal fossa. Cæcum has been pulled upward and to the right. The specimen presented a variation in the form of a smaller pocket within a larger one.

behind a fold of peritoneum which is usually vascular, containing either a tributary of the left colic or of the middle colic vein; its orifice looks downward.

The **mesocolic fossa,** situated over the terminal part of the fourth segment of the duodenum behind a fold of peritoneum connected with the transverse mesocolon, is of less common occurrence than the other two.

The **paraduodenal fossa** is a little pocket sometimes found situated to the left of the fourth part of the duodenum and opening to the left.

The **retroduodenal fossa** is situated behind the third and fourth parts of the duodenum. It must not be understood that any one subject presents all of these fossæ.

The clinical interest attached to these peritoneal pockets hinges upon the fact that a small portion of intestine may become lodged in one of them, constituting a form of *retro-peritoneal* or *internal hernia.*

THE ILEO-CÆCAL JUNCTION. — The **superior ileo=cæcal** fossa is found in the upper angle of this junction. Displacing the coils of jejuno-ileum to the left side of the abdomen the junction of the ileum with the cæcum should be noted. This peritoneal pocket is bounded anteriorly by a fold which is raised by the cæcal branch of the ileo-colic artery (Fig. 312).

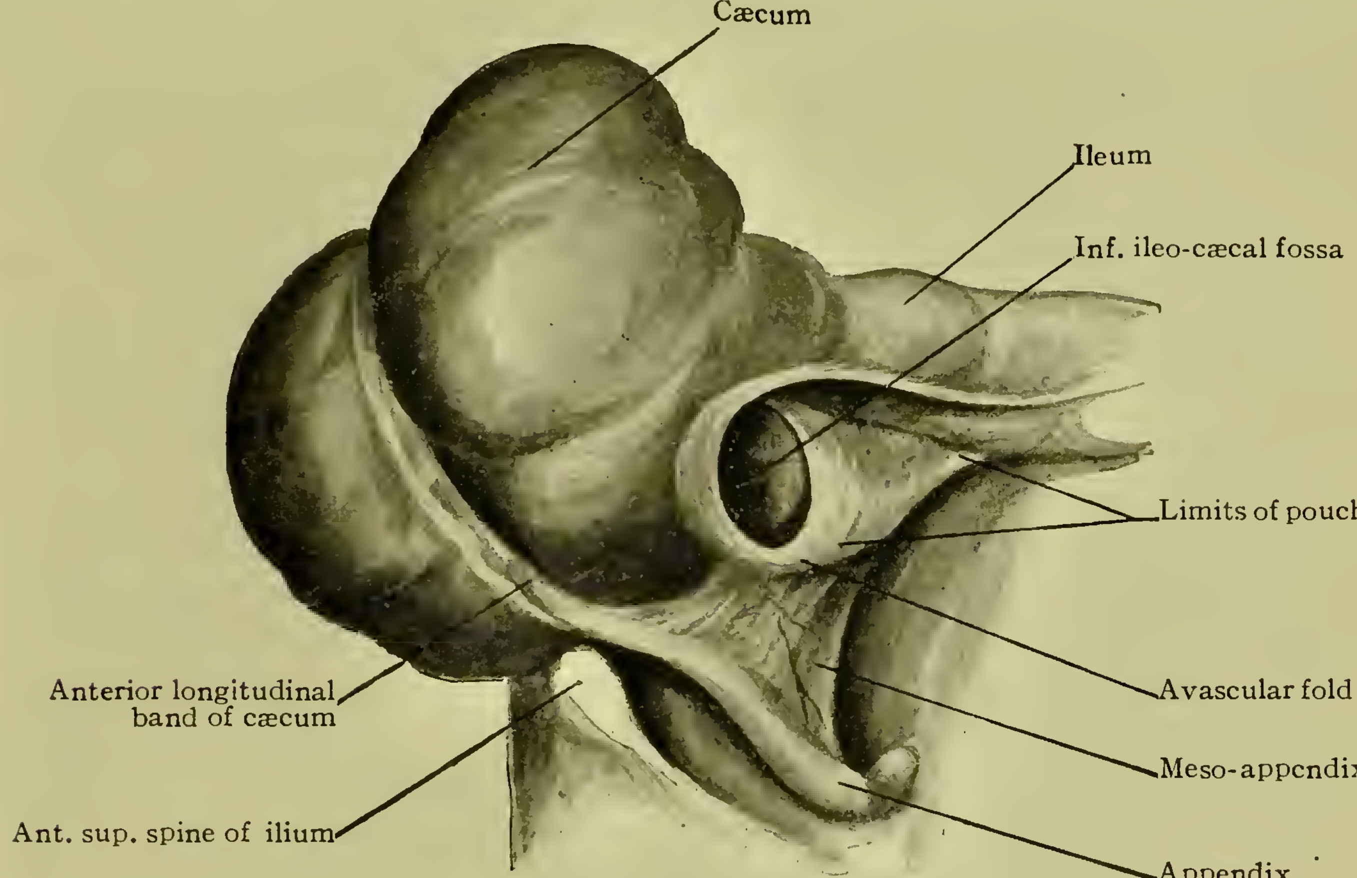

FIG. 313.—Inferior ileo-cæcal fossa. Cæcum has been displaced upward and outward.

The **inferior ileo=cæcal fossa** may be exposed by drawing the cæcum somewhat to the right and the termination of the ileum somewhat upward (Fig. 313). The *bloodless fold of Treves* is a layer of peritoneum which passes from the anterior surface of the ileum and the antero-internal surface of the cæcum to the mesentery of the appendix, which latter must be made taut by pulling downward and to the right the tip of the appendix. The fossa is bounded in front by the bloodless fold, behind by the meso-appendix, above by the ileum and on the right side by the cæcum. Its orifice sometimes points to the right and sometimes directly forward as shown in Fig. 313.

The **retro-cæcal** or **retro-colic fossa** may be exposed by elevating the lower extremity of the cæcum, the peritoneum as it is reflected from the posterior surface of the cæcum to the iliac fossa enclosing the pocket in question.

The Blood-Supply of the Small Intestine.—This includes the superior pancreatico-duodenal artery from the gastro-duodenal of the hepatic and the inferior pancreatico-duodenal of the superior mesenteric for the duodenum; the vasa intestina tenuis and a part of the ileo-colic of the superior mesenteric for the jejunum and ileum. Displacing the coils of jejunum and ileum to the left side of the abdomen, the right layer of the mesentery must be cut or removed to expose these vessels.

The **superior mesenteric artery** may be recognized at the upper part of the attachment of the mesentery, by palpation, if it is not visible through the peritoneum, and should be exposed. Traced upward it will be noted to emerge from between the pancreas and the duodenum (Fig. 309) immediately after its **origin** from the abdominal aorta. The sympathetic plexus of the superior mesenteric, a branch of the solar plexus, invests the artery and gives branches in the form of small plexuses to the various **branches** of the artery, the *inferior pancreatico-duodenal*, the *vasa intestini tenuis*, the *ileo-colic*, *colica dextra* and *colica media*.

The **inferior pancreatico-duodenal artery** (Fig. 321), arising usually between the pancreas and the transverse part of the duodenum, the first branch, may be dissected later (p. 655).

The **intestinal branches,** *vasa intestini tenuis*, come off successively from the superior mesenteric, each artery bifurcating, each bifurcation forming an anastomotic loop with the neighboring branch, from the convexities of which loops other branches arise, these in turn bifurcating to form a second series of loops, this process being repeated until sometimes a fourth series of loops is formed. Upon reaching the bowel, branches pass to each surface—that is, to each side of the line of attachment of the mesentery. The *sympathetic plexuses* of these vessels accompany them to the intestine (Fig. 309).

The **veins** of the small intestine closely correspond in arrangement with the arteries, the various venous trunks converging finally to the **superior mesenteric vein** (Fig. 309).

The **lymphatics** of the mesentery include the lymph-vessels (the system of lacteals) and the lymph-nodes.

The lymph-nodes of the mesentery are liable to inflammation and consequent enlargement in abdominal tuberculosis, in which case they are palpable through the abdominal wall.

The jejunum and ileum may now be removed, two ligatures being applied to the bowel at the beginning of the jejunum and two at the termination of the ileum, the intestine being cut between the ligatures in each case. The mesentery may be divided within an inch or two of

its intestinal attachment. These portions of the small intestine may now be studied more in detail by taking a segment of about six inches from the beginning of the jejunum, another segment of similar size five or six feet farther along, and several segments from the ileum. Washing out these portions of the intestine they may be laid open by an incision with scissors along the attached margin in some cases and in other cases by an incision along the distal margin of the bowel.

The **valvulæ conniventes** (plicæ circulares) are seen as transverse crescentic folds, chiefly on the attached side of the bowel and including from one third to two thirds of its lumen, which serve to increase the absorptive area as well as to retard the progress of the intestinal contents. Their varying size should be noted in different parts of the bowel; they are largest in the second part of the duodenum where they begin, and gradually diminish in size as the lower part of the ileum is reached. They are permanent folds.

The **villi** are small elevations, barely visible to the naked eye, which likewise increase the absorptive area and are largest and best developed in the second part of the duodenum.

The **crypts of Lieberkühn,** simple follicular or tubular glands, the orifices of which may be detected by the aid of a hand glass, are scattered over the intestinal mucosa. They are distributed throughout the entire length of both small and large intestines.

The **solitary glands,** not true glands but small nodules of lymphoid tissue, appear as very slight elevations, .2 to 2 or 3 mm. in diameter, upon the surface of the mucosa throughout the small and large intestines.

The **agminate glands** or **Peyer's patches,** consisting of collections of the solitary lymph-nodules, may be detected as slight elevations of the mucosa varying in extent from one third of an inch to two, three or four inches in length, situated usually on the distal wall of the bowel. They are most abundant near the termination of the ileum.

Meckel's diverticulum may sometimes be found attached to the ileum at some point within three feet of its termination. It represents the persistent proximal portion of the vitelline duct which normally completely disappears. When present it is usually of the calibre of the bowel to which it is attached and may have a length of from one to two or three inches.

The diverticulum of Meckel may become the seat of fecal impaction with resulting inflammation, as a consequence of which it may acquire adhesion to the adjacent coils of bowel and so become a cause of *acute intestinal obstruction.*

The Large Intestine.—The large intestine consists of the *colon* and the *rectum.* The **colon** includes the *cæcum* or *caput coli*, the *ascending*, the *transverse*, the *descending* and the *sigmoid colon.* The gross characters of the colon as compared with the small intestine are its comparatively fixed position, its wider calibre, its shorter length, its relation

to the peritoneum—being less completely invested by that membrane—the *appendices epiploicæ* or little peritoneal pockets containing fat which are found upon its surface, its *sacculated condition* and the *three longitudinal bands* (tæniæ coli) visible upon its surface. One *longitudinal band* is found on the anterior surface, one on the posterior surface and one on

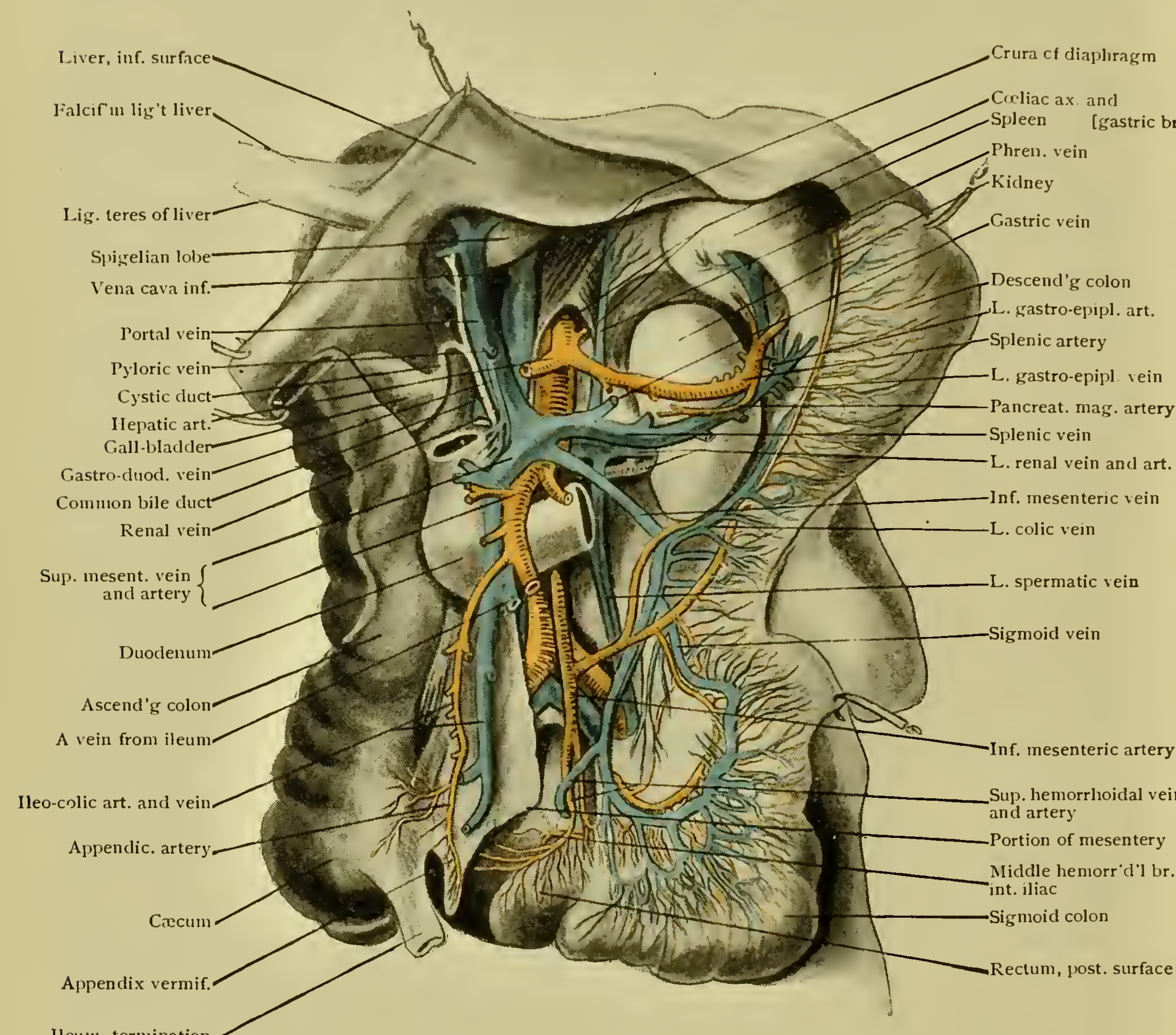

Fig. 314.—Blood-vessels of large intestine showing tributaries of portal vein. The stomach and transverse colon have been removed and the liver pulled upward. The portal vein is seen to break up into branches as it enters the liver, the hepatic duct lying in front of it as it passes to join the cystic duct.

the mesial surface of the ascending and of the descending colon and on the inferior surface of the transverse colon. The muscular bands represent the longitudinal muscular coat of the bowel localized in the three positions mentioned instead of forming a continuous tunic as in the case of the small intestine. It is their shortness as compared with the other constituents of the walls that is responsible for the sacculated condition of the colon.

The Cæcum.—The cæcum or caput coli, having a transverse diameter of three inches and a vertical diameter of two and one half inches, lies in the iliac fossa in contact with the iliacus and psoas muscles. Its relation to the peritoneum is such that it receives a complete investment but is usually devoid of a mesentery. The peritoneum should be followed from the small intestine and its mesentery over the cæcum, and its reflection from the cæcum to the iliac fossa in such manner as to enclose the retro-cæcal fossa noted. The saccule upon the right side of the anterior longitudinal band is usually larger than the left saccule. *Variations of the form* of the cæcum occur: (a) the two saccules may be symmetrical as to size; (b) the right may be very much larger than the left; (c) they may be scarcely existent as saccules, the lower end of the cæcum tapering away into the appendix, giving the cæcum the conical form which is known as the *fetal type*. *Variations in the position* of the cæcum also occur, due to arrested development, the cæcum either remaining under the liver or opposite the crest of the ilium. Another variation in position, sometimes seen, associated with over-growth of the ascending colon, is that condition in which the cæcum is directly over the superior aperture of the pelvis, the ascending colon then passing upward and to the right to gain its usual position.

The **ileo=cæcal valve** (valvula coli), the aperture by which the ileum opens into the cæcum and ascending colon, is at the postero-internal aspect of the cæcum at its point of junction with the ascending colon. This may be inspected by an incision into the anterior wall of the cæcum as directed below, after the examination of the ascending colon.

The Vermiform Appendix.—The attachment of the vermiform to the cæcum is a little way below the position of the ileo-cæcal valve. If the dissector will follow the anterior longitudinal band of the cæcum downward around its lower surface to its postero-internal aspect, he will be guided by it to the proximal end of the appendix (Fig. 313). The calibre of the appendix he will note to be that of an ordinary goose-quill, while its length varies from one inch to three inches and in extreme cases may be increased to eleven inches.

The **relation of the appendix** to the peritoneum is such that it receives a complete investment and has a small mesentery or meso-appendix which, however, does not extend quite to the tip of the organ. If the tip of the appendix be pulled downward so as to make its mesentery tense, the anterior layer of the meso-appendix may be cut through and the branches of the **appendicular artery** may be dissected. This vessel arises from a branch of the ileo-colic artery and passes behind the termination of the ileum to reach the meso-appendix, where it forms a series of small loops similar to those of the vasa intestini tenuis (Fig. 314). The twisted condition of the appendix is thought to be due to the shortness of its line of attachment to its mesentery.

The **position** of the appendix varies greatly; it sometimes points upward behind the cæcum and ascending colon, sometimes upward and to the left, sometimes straight downward, or it may pass over the pelvic brim into the pelvic cavity. It may also pass into the inguinal canal, even the canal of the left side (Treves).

The **liability of the appendix to inflammation** is due to several causes. The fact that it is a *rudimentary organ*, or an organ in process of regressive evolution, is possibly one of the most potent of these causes. An appendix vermiformis is found only in man, the wombat and in some anthropoid apes, *i.e.*, in these, the distal part of the cæcum of fetal life lags behind in development and remains a tube of small calibre as compared with the adult cæcum. The appendix is therefore an aborted and functionless part of the cæcum, and the human cæcum and appendix represent, in rudimentary form, the very capacious cæcum of the koala, or kangaroo bear, that has a cæcum three times the length of its body, and the less marked examples of large cæcum seen in the horse (cæcum two and a half feet long) and in rodents. It is noteworthy that animals with large cæca have simple stomachs, while those possessing a more complicated stomach have no cæcum (sloth) or a rudimentary one. The *small calibre* of the appendix, the *poorly developed muscular element of its walls*, its *blind end* and its *situation with relation to the cæcum* are also extremely important factors in the production of inflammation, since they are conditions which favor the entrance of micro-organisms, fecal matter and small foreign bodies into the appendix and encourage their remaining there.

The abundance of lymphoid tissue within the walls of the appendix is another important factor in its liability to inflammatory conditions.

The point of greatest tenderness in appendicitis, *McBurney's point*, is about the middle of a line extending from the anterior superior spine of the ilium to the umbilicus.

The Ascending Colon.—The length of the ascending colon is eight inches. The dissector will trace it from the position of the cæcum to the *hepatic flexure* in contact with the colic impression on the under surface of the liver. Of the epiploic appendages, the sacculated condition and the longitudinal bands of the colon, *tæniæ coli*, sufficient mention has been made. The relation of the ascending colon to the peritoneum has been pointed out, the usual relation being the investment of the anterior and the inner and outer surfaces with this membrane, the posterior surface being non-peritoneal. The investing layer of peritoneum which is reflected from the posterior abdominal wall upon the right side of the mesentery to the ascending colon should be traced over the colon and back again to the posterior wall of the abdomen upon the right side of the colon. An important variation of this arrangement is found in about twenty-six per cent. of all cases, the variation consisting in the complete investment of the ascending colon with peritoneum and the consequent presence of a mesentery or ascending mesocolon.

The **blood=supply** of the ascending colon is from the ileo-colic artery and the right colic or colica dextra, branches of the superior mesenteric artery (Fig. 314). These vessels should now be traced, the peritoneum which covers them being necessarily cut through for the purpose. Each of the vessels is accompanied by its own sympathetic plexus of nerves

from the superior mesenteric plexus. The **veins** correspond to the arteries and are tributaries of the superior mesenteric vein.

The *posterior relations* of the ascending colon may be noted by cutting or tearing through the parietal peritoneum on the outer side of the tube, bringing into view the quadratus lumborum muscle and the anterior surface of the right kidney against which the colon rests, to the outer side of the descending part of the duodenum. The hepatic flexure of the colon should be noted in its relation to the under surface of the liver, as well as the depth of this part of the colon from the anterior wall of the

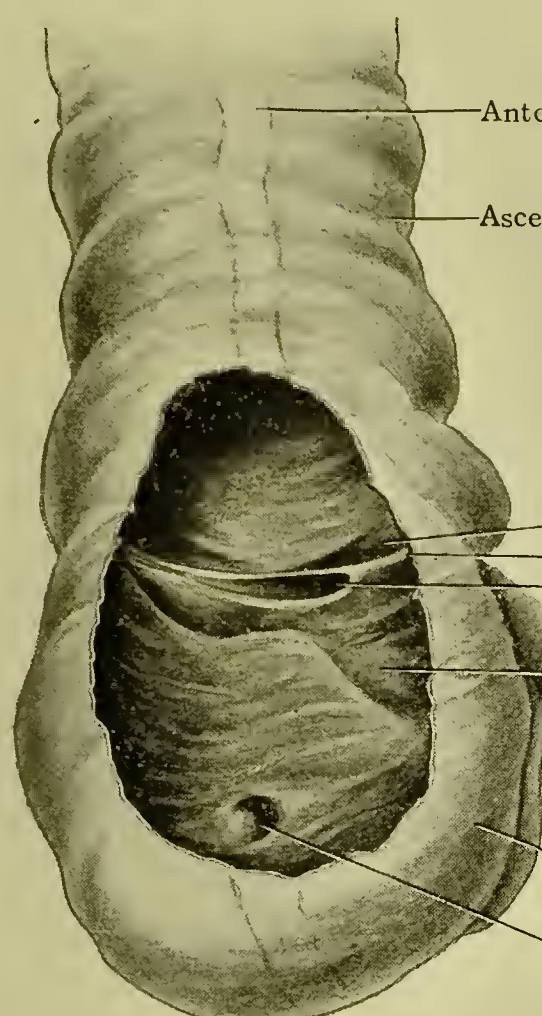

FIG. 315.—Beginning of large intestine, somewhat inflated; part of anterior wall removed to show ileo-cæcal valve and orifice of vermiform appendix.

abdomen and the fold of peritoneum, the *sustentaculum hepatis*, which passes from it to the lateral abdominal wall above the crest of the ilium.

The Interior of the Cæcum.—A ligature should now be placed around the middle of the ascending colon and one around the ileum near its termination. The cæcum may now be opened by a vertical incision external to the anterior longitudinal band. Retracting the edges of the cut will permit the inspection of the interior of the cæcum.

The **ileo=cæcal orifice** appears on the postero-internal aspect of the cæcum at its junction with the ascending colon, as a transverse slit somewhat rounded at its inner angle, bounded by two folds, one, the *ileo-colic*, above, the other, the *ileo-cæcal*, below, forming the **ileo=cæcal**

valve (Fig. 315). At the angles of the opening, the folds coalesce to be prolonged as the *anterior* and *posterior retinacula or frenula*, of which the latter is the larger. The valve folds are covered with villi on the ileal surfaces.

The *orifice of the appendix* (Fig. 315) will be seen at some distance below the ileo-cæcal valve.

The **position** of the ileo-cæcal valve is beneath a point on the abdominal wall one to two inches to the inner side of and above the anterior superior spine of the ilium.

The ileo-cæcal region is the favorite seat of **intussusception** (the slipping of a segment of bowel into the succeeding segment), which occurs most often in children.

The most common form of intussusception is the *ileo-cæcal*, in which the ileum and cæcum constitute the intussusceptum, or part received, the ileo-cæcal valve being at its apex, the colon being the intussuscipiens or receiving part. The intussusceptum may pass through the colon and rectum to the anus. *Ileo-colic intussusception*, the ileum passing through the valve into the colon, the cæcum not participating, occurs much more rarely.

The Transverse Colon.—This portion of the colon has a length of from seventeen to twenty inches. Beginning at the hepatic flexure and terminating at the splenic flexure, it curves both forward and downward in crossing the abdomen. The level to which the most convex portion of the curve descends varies in individual cases. The relation of the transverse colon to the peritoneum has been pointed out in tracing that membrane and may be demonstrated now by the dissector if he will raise the colon and note the attachment to it of the great omentum and of the transverse mesocolon, this part of the tube having a complete investment of peritoneum and its own mesentery, the **mesocolon.** The dissector should note that the great omentum passes from the greater curvature of the stomach directly in front of the transverse colon, to which it usually adheres, and that if this layer be torn through, the upper layer of the transverse mesocolon will be exposed and may be traced backward below the greater curvature of the stomach to the posterior abdominal wall where it passes upward over the pancreas. Now, if the transverse colon and the stomach be elevated, the under layer of the transverse mesocolon will be exposed and may be traced to the abdominal wall and downward over the transverse part of the duodenum to become continuous with the parietal peritoneum.

The **blood-supply** of the transverse colon is from the colica media or middle colic branch of the superior mesenteric artery, supplemented on the right side by branches from the colica dextra and on the left by branches from the colica sinistra or left colic of the inferior mesenteric artery. These vessels should now be dissected, the transverse colon remaining in the position shown in Fig. 309, the arteries being exposed by cutting through the lower layer of the transverse mesocolon. The

terminal parts of these arteries were found in a previous stage of the work as they perforated the anterior layer of the great omentum on their way to the anterior surface of the transverse colon (Fig. 308). What was said in the preceding section concerning the *accompanying veins* and *sympathetic plexuses* applies with equal force in the present instance.

The **inferior pancreatico-duodenal artery,** a branch of the superior mesenteric, arising near the beginning of that vessel as it passes between the pancreas and the transverse part of the duodenum, should now be identified and exposed (Fig. 321), its *branches* to the duodenum and the pancreas respectively being traced.

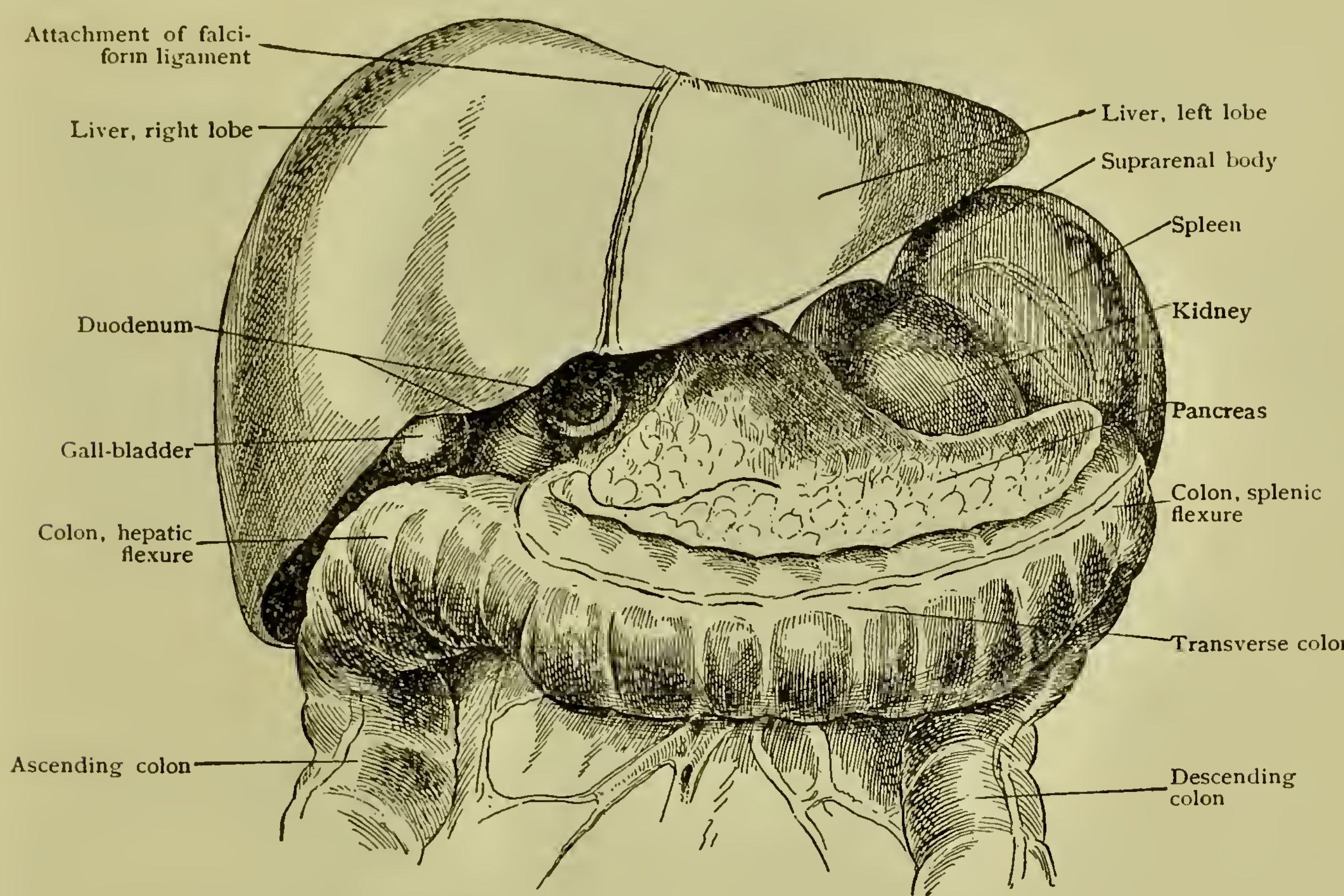

Fig. 316.—Viscera of upper abdomen, anterior view. The stomach removed to show the stomach chamber. (His model.)

The **splenic flexure** of the colon, the termination of the transverse and the beginning of the descending colon, is in contact with the lower outer portion of the anterior surface of the spleen. The **sustentaculum lienis** or suspensory ligament of the colon (Fig. 317) should be noted as a fold of peritoneum connecting the splenic flexure with the diaphragm in the vicinity of the tenth rib and passing immediately under the lower border of the spleen, forming a sort of shelf for the latter.

The Posterior Wall of the Stomach.—With the stomach turned upward, the *vessels* and *nerves* of its posterior wall should be examined. The **vessels** are branches of those already encountered along the two borders of the viscus (Fig. 309).

The **right pneumogastric nerve,** which breaks up here into branches that form the *posterior gastric plexus*, should be identified and dissected. After following the *gastric branches* of this plexus to the stomach wall, its *cœliac branches* should be followed along the gastric artery to the cœliac plexus of the cœliac axis, from which, through the solar plexus, they are distributed, through the superior mesenteric, splenic, pancreatic, renal and suprarenal plexuses, to the parts supplied by these plexuses.

THE DESCENDING COLON.—The descending colon, beginning at the splenic flexure and ending in the sigmoid colon at the outer border of the left psoas muscle, has a length of eight to eight and one half inches.

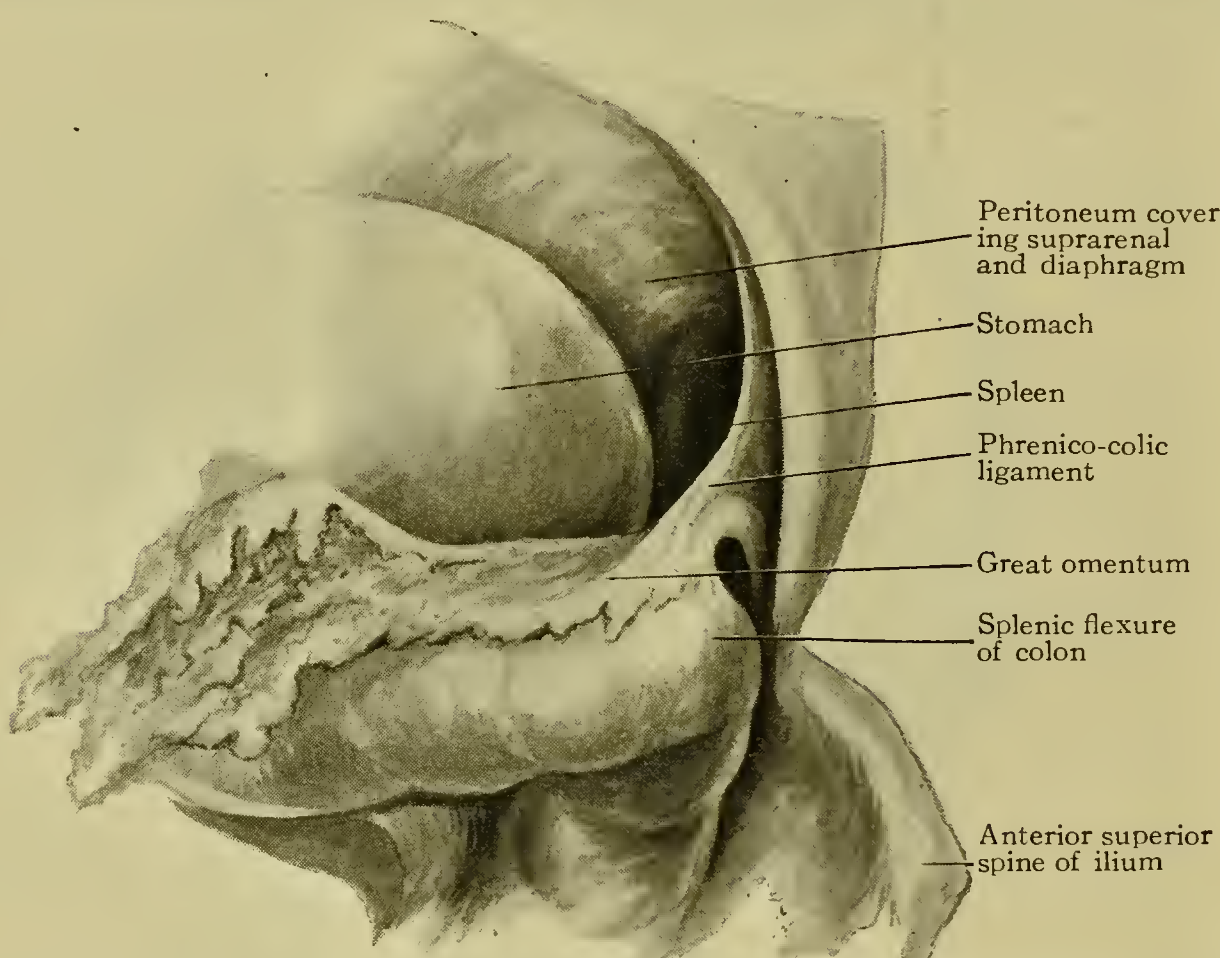

FIG. 317.—Splenic flexure of colon and phrenico-colic ligament (sustentaculum lienis).

The peritoneal relations of the descending colon are like those of the ascending colon, that is, the posterior wall is without peritoneal covering, except that, in a larger proportion of cases, thirty-six per cent. (Treves), it is completely invested with peritoneum and has a mesentery.

This relation of the peritoneum to the descending colon has an important bearing upon the operation of **lumbar colostomy,** an operation performed for the relief of either *fibrous* or *malignant stricture* of the lower part of the colon or of the sigmoid. This operation may be done as an extraperitoneal operation in those cases in which the posterior surface of the colon is without peritoneal covering, the bowel then being approached through the loin and between the layers of peritoneum which connect the colon with the abdominal wall; if, however, the colon is completely invested with peritoneum the operation is necessarily an intraperitoneal operation and opens up the peritoneal cavity.

The **blood-supply** of the descending colon is from the colica sinistra of the inferior mesenteric artery and the ascending branches of the sigmoid artery (Fig. 314). These vessels should now be dissected. The **inferior mesenteric artery** should be exposed at its origin from the abdominal aorta a short distance below the origin of the superior mesenteric and should be traced downward and to the left as far as the crest of the ilium; its branches to the descending colon, noted above, should be followed to their terminations. The *sympathetic plexus* accompanying the artery should be dissected, at least in part.

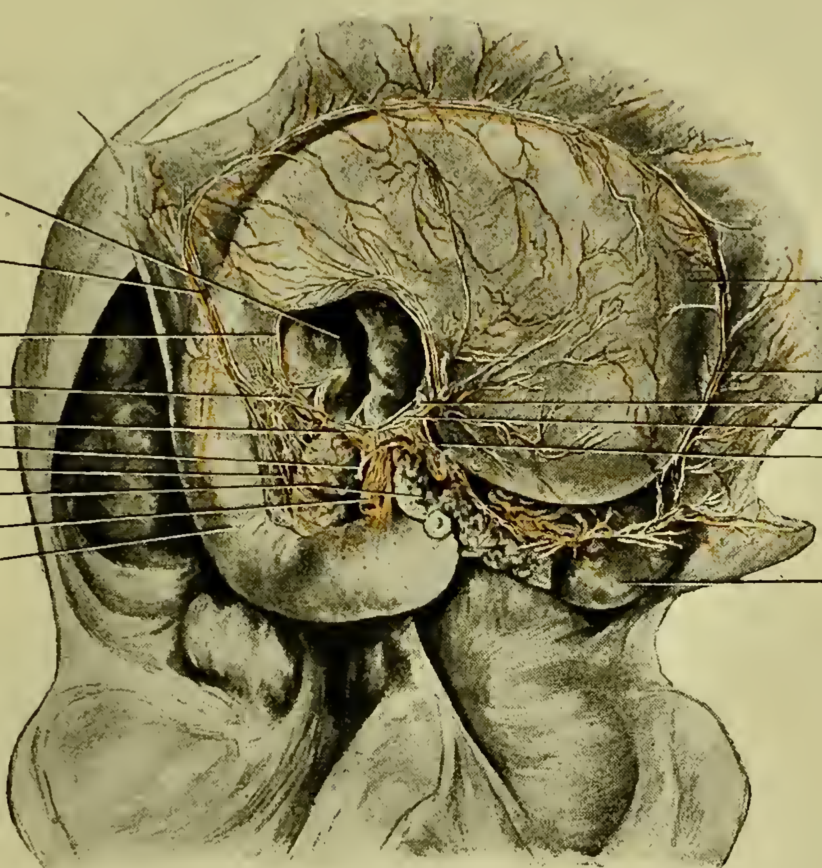

FIG. 318.—Dissection showing gastric, hepatic and splenic plexuses; stomach has been turned up and part of pancreas removed.

The *posterior relations* of the descending colon may be demonstrated by incising the peritoneum either to the right or to the left of the bowel, when the relation of the colon to the spleen, the lower outer portion of the left kidney, the left crus of the diaphragm and the quadratus lumborum will be seen.

THE SIGMOID COLON.—The sigmoid colon, pelvic colon, sigmoid flexure or omega loop, begins at the outer border of the psoas or near the crest of the ilium where the descending colon ends and terminates opposite the third piece of the sacrum, where it becomes continuous with the first part of the rectum. It thus includes what was formerly described as the sigmoid flexure and the first part of the rectum. Its length is from ten to eighteen inches (Fig. 319). If the coils of this part

of the colon be unfolded so that its mesentery lies spread out, the reason for the name *omega loop* becomes apparent. The position of the sigmoid colon is in the pelvic cavity—hence the name *pelvic colon*—except when distended, in which case it is compelled to leave the pelvic cavity and to assume a position in the lower part of the abdominal cavity. The *peritoneal relations* of the sigmoid differ from those of the ascending and descending parts of the colon in that it has a complete investment and a distinct mesentery, the *mesosigmoid* or *pelvic mesocolon.*

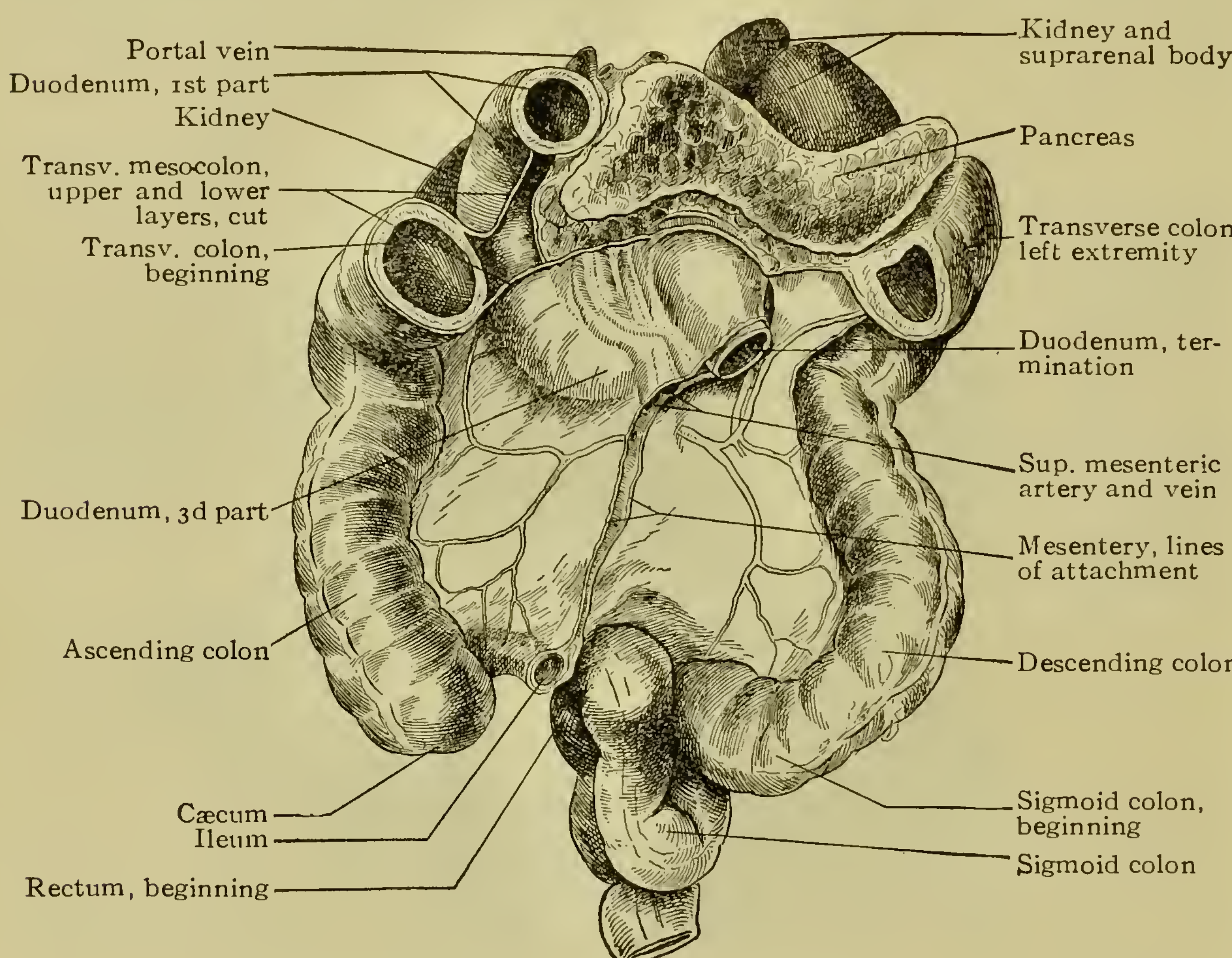

Fig. 319.—Anterior view of pancreas, duodenum, and large intestine, a part of transverse colon having been removed. (From photograph of His model.)

The line of attachment of the mesosigmoid to the posterior abdominal wall begins above on the left side of the left psoas muscle, crosses the psoas and the iliac vessels near the bifurcation of the common iliac artery to the lateral and then to the posterior wall of the pelvic cavity, approaching the mid-line opposite the third piece of the sacrum. Here it ends by the separation of its two layers, which are continued downward to invest the upper part of the front surface of the rectum. The **intersigmoid fossa,** a peritoneal pouch bounded by a fold raised by the sigmoid artery, is exposed by pulling the sigmoid colon downward and to the left (Fig. 320), or by displacing it to the right.

The **blood=supply** of the sigmoid colon is from the inferior mesenteric artery through the **sigmoid artery** and its *branches*. These vessels should be exposed by cutting through the anterior layer of the mesosigmoid and following them and their branches to the bowel (Fig. 314), the vessels forming a series of loops similar to those of the vasa intestini tenuis.

The **inferior mesenteric artery** may now be followed from its origin to its termination, the only one of its **branches** not thus far dissected being the *superior hemorrhoidal*, which should be followed downward

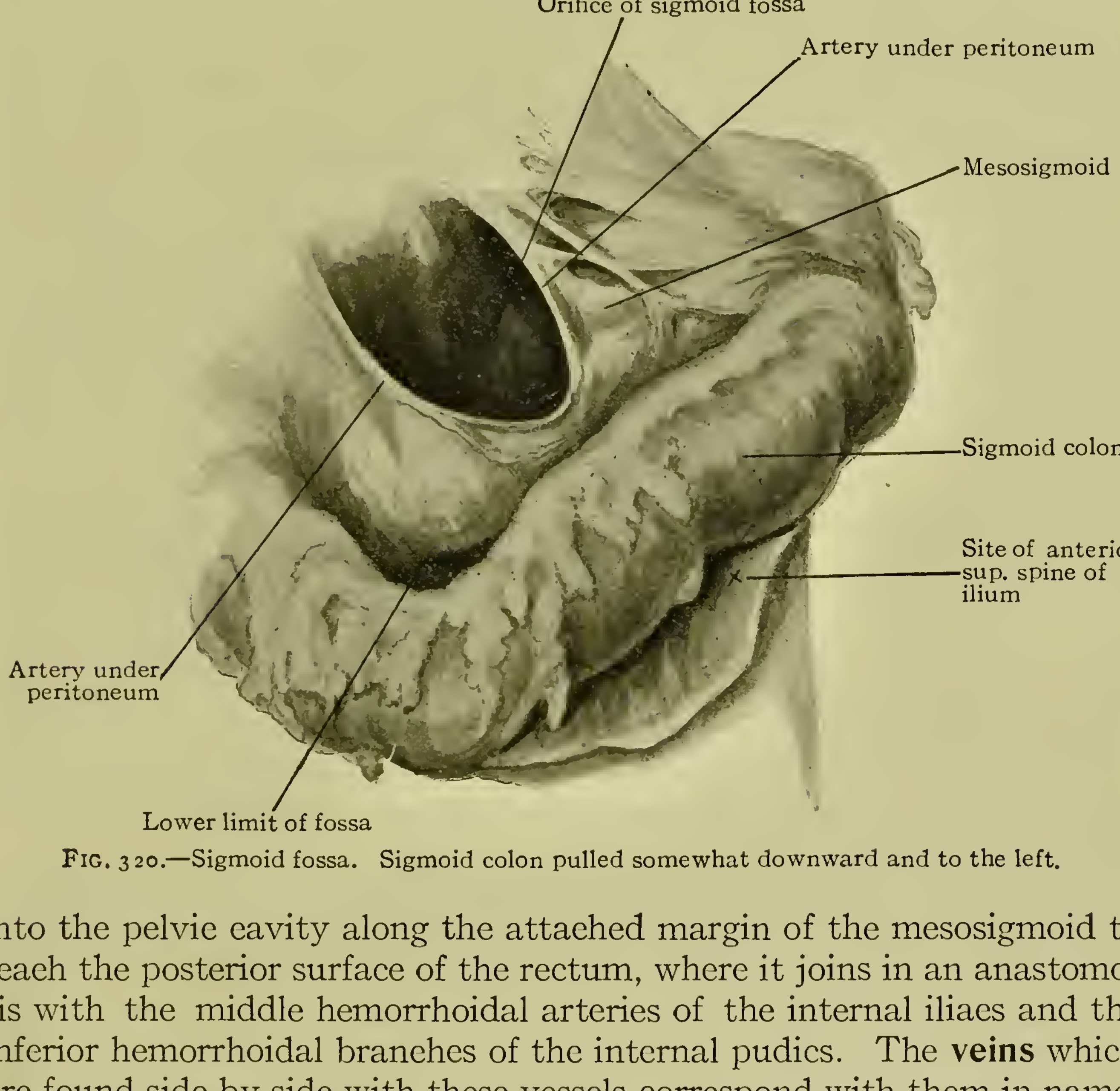

FIG. 320.—Sigmoid fossa. Sigmoid colon pulled somewhat downward and to the left.

into the pelvic cavity along the attached margin of the mesosigmoid to reach the posterior surface of the rectum, where it joins in an anastomosis with the middle hemorrhoidal arteries of the internal iliacs and the inferior hemorrhoidal branches of the internal pudics. The **veins** which are found side by side with these vessels correspond with them in name, the *superior hemorrhoidal vein* coming from the hemorrhoidal plexus and emptying into the inferior mesenteric vein and so becoming a link which connects the portal venous system with the general venous system as previously noted (p. 640).

The *intersigmoid fossa* may be the seat of *sigmoid hernia*. The length of the sigmoid colon as compared with that of the line of parietal attachment of its mesentery favors the formation of rather sharp curvatures which effectually bar the pas-

sage of the long rectal tube into the descending colon. These curvatures may easily become pathological, so that the sigmoid colon is the favorite seat of that form of acute intestinal obstruction known as *volvulus.*

The sigmoid colon is opened for the purpose of establishing an *artificial anus* in case of imperforate rectum (*left inguinal or iliac colotomy or colostomy*).

The Duodenum.—The examination of this part of the small intestine was necessarily deferred until this stage on account of its position. The duodenum is the shortest of the subdivisions of the small intestine—its *length* being ten to twelve inches—the widest in calibre, the most vascular, the most fixed in position and the only part of the small intestine which is not completely invested with peritoneum. Restoring the stomach to its normal position, the **first part of the duodenum,** having a length of two inches and beginning at the pyloric end of the stomach, should be traced upward, backward and to the right to the beginning of the second part. The first part of the first portion is completely invested with the peritoneum of the lesser omentum, while the remaining portion has peritoneum only on its anterior surface. It comes into relation above with the quadrate lobe and with the duodenal impression on the under surface of the right lobe of the liver and with the neck of the gall-bladder. Behind it, are the common bile duct, the portal vein and the gastro-duodenal artery; below it, is the pancreas.

The **second** or **descending part of the duodenum,** having a length of three inches, begins at the under surface of the liver and ends opposite the third or fourth lumbar vertebra. Its anterior surface is covered with peritoneum and comes into relation with the beginning of the transverse colon; its posterior surface is in contact with the left portion of the anterior surface of the right kidney and the renal vessels; on its outer side it is related with the ascending colon; on its inner side with the head of the pancreas, the common bile duct and the pancreatic duct being between them.

The **third** or **transverse part,** having a length of four inches, begins at the right side of the third (or fourth) lumbar vertebra and terminates at the left side of the second. It is in relation by its anterior surface with the upper layer of the transverse mesocolon; by its posterior surface with the spine, the vena cava, and, in some cases, with the aorta; by its upper surface with the pancreas, the superior mesenteric artery and vein emerging between the two. The very close relation between the second and third parts of the duodenum and the head of the pancreas should be noted, the surface of that part of the pancreas in contact with the duodenum being moulded to the convexity of the bowel.

The **fourth** or **second ascending portion,** having a length of one and one half inches, begins at the left side of the second lumbar vertebra and passes upward and forward to become continuous with the jejunum.

The termination of the duodenum is held in place by a triangular band of fibrous and muscular tissue, the *ligament of Treitz* (Fig. 311), which connects it with the left crus of the diaphragm near the cœliac axis. The fourth part of the duodenum has peritoneum on its anterior surface only, except at its termination, where it receives a complete investment. Thus it is evident that the duodenum is for the most part retroperitoneal, being completely invested with this membrane only at its two extremities. What has been described above as the course or shape of the duodenum is subject to considerable variation, the form sometimes being markedly triangular instead of describing the form of the letter C.

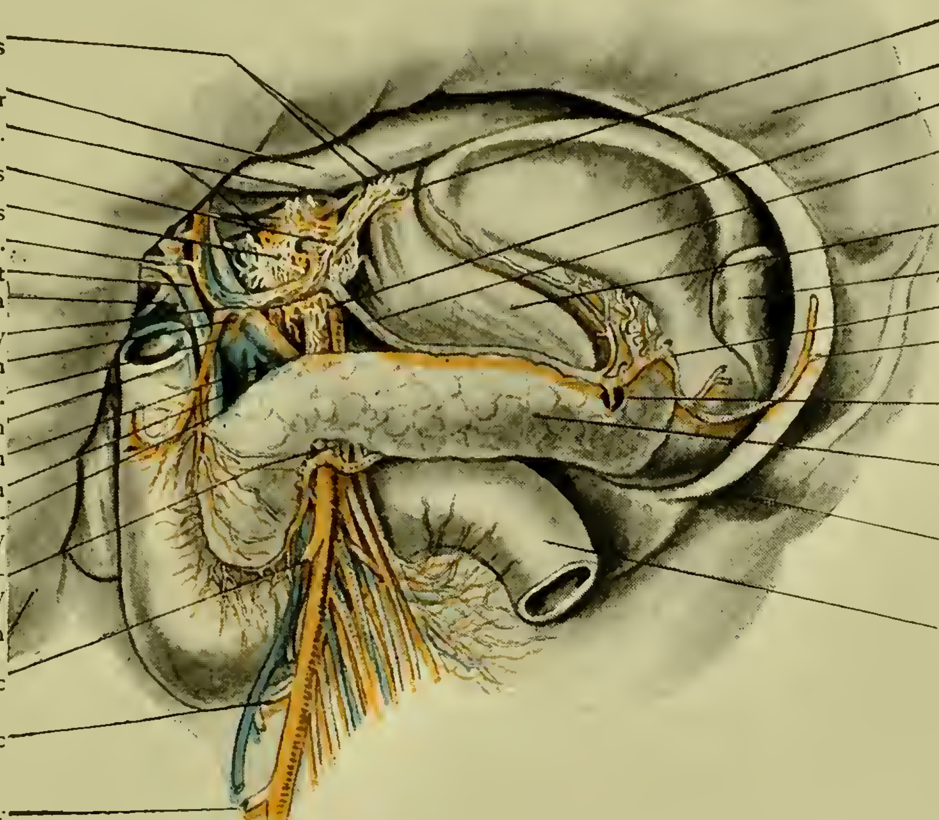

FIG. 321.—Cœliac axis and its branches; stomach has been removed and transverse colon turned up.

The **interior of the duodenum** should be exposed by incising the descending portion along its antero-external aspect, though it is rather better to defer this until after the study of the pancreas. After noting the valvulæ conniventes in the lower half of this part of the bowel, try to identify the orifice of the common bile duct on the left wall, two inches from the beginning of this segment, and pass a probe into it. If not discoverable, pass a probe through the duct from above, opening the gall-bladder if necessary.

The Dissection of the Stomach.—The stomach may now be removed from the abdominal cavity, two ligatures first being applied around the lower end of the œsophagus and a cut being made between them, two also being applied to the beginning of the duodenum between which the latter is to be cut.

The gastro-splenic omentum must also be divided as well as any peritoneal folds or vessels still connecting the stomach with other organs.

The stomach being moderately inflated with air, the **outer serous** or **peritoneal coat** may be removed, largely by stripping it off with the fingers.

The **second** or **muscular tunic** now exposed should be recognized as consisting of an *outer longitudinal layer*, best developed along the lesser curvature; a *middle circular layer*, absent from the region of the fundus; and an *inner oblique layer*, continued from the deep circular fibres of the œsophagus, which is limited to the fundus region.

The **pyloric sphincter** should be demonstrated as an aggregation of the middle circular muscular fibres at the pyloric orifice.

The **third tunic,** the **submucosa,** may be partially demonstrated by raising the muscular fibres throughout a small area.

The **innermost tunic,** the **mucosa,** is to be studied after having opened the stomach by cutting its wall with scissors along the lesser curvature. It should be thoroughly cleansed in running water. Its looseness and tendency to form folds and the facility with which it may be shifted should be noted, these features being related to the loose arrangement of the submucosa and to the presence of the *rugæ* or mucous folds of the undistended stomach, which become effaced in distention.

Examination with a lens will disclose *pits* which contain the small apertures of the **pyloric** and **gastric glands.**

The *inner aspect of the pyloric orifice* or canal should also be examined.

The Pancreas.—The pancreas, being a retro-peritoneal organ, the layer of peritoneum which is continued from the upper or ascending layer of the transverse mesocolon over the anterior surface of the pancreas must be removed to expose it. The texture of the pancreas is such that it does not retain its form unless hardened in position before the disturbance of adjacent organs, and consequently its dissection is somewhat difficult. The **position** of the pancreas is in the posterior portion of the abdominal cavity opposite the first and second lumbar vertebræ, occupying the epigastrium and the left hypochondrium. The enlarged right extremity or **head** is connected by a constriction, the **neck,** with the **body** of the organ, which tapers away to some extent to the left extremity or **tail.** The **surfaces** presented by the pancreas are an *antero-superior* surface looking upward and forward, a *posterior* surface and an *inferior* surface (Fig. 316).

The Relations of the Pancreas.—The **antero-superior surface,** which is concave, is in contact with the convex posterior surface of the stomach, being separated from it by the parietal and visceral layers of the lesser peritoneal sac (Fig. 303).

The **inferior surface** *of the head* is in relation with the transverse portion of the duodenum, emerging between which structure and the pancreas, to the left of its head, will be seen the superior mesenteric artery and vein. These vessels should be followed by displacing the pancreas slightly upward. The *body* rests against the lower layer of the transverse mesocolon and the duodeno-jejunal curve.

The **posterior surface,** non-peritoneal, is in relation at the right, the *head*, with the inferior vena cava, the right renal vein and the common bile duct; the *neck*, with the portal vein; the *body*, with the aorta, the splenic artery, the splenic vein, the left crus of the diaphragm and, near the left extremity, the pancreatic surface of the left adrenal and of the left kidney; quite at the left extremity it is in relation with the anterior surface of the spleen. It will not be possible to verify all of these relations at the present stage of the dissection. The head of the pancreas is embraced by the descending and transverse parts of the duodenum, presenting a surface which is concave and accurately moulded to the convexity of these portions of the duodenum. The head should be separated slightly from the descending duodenum to bring to view the termination of the common bile duct and of the pancreatic duct or duct of Wirsung. At the lower part of this interval the *superior pancreatico-duodenal artery*, a branch of the gastro-duodenal, will be found sending branches to the head of the pancreas and to the duodenum. If the bile duct has been demonstrated by the passage of the probe, as directed previously, the orifice of the pancreatic duct, whether it be a separate orifice or whether it exist in common with the orifice of the bile duct, may perhaps be found and demonstrated by a second probe, access being gained to the ducts by opening the right side of the descending portion of the duodenum to expose the terminations of the ducts, if this has not been done.

The **splenic artery** (a. lienalis) (Fig. 314), the largest of the three branches of the cœliac axis, should be traced from its origin toward the left along the posterior surface of the pancreas near its upper border, the latter being pulled down slightly to expose the artery. The dissector will note the tortuosity of this vessel as well as its large size, and will detect its **branches** as the *great pancreatic* (Fig. 321), the *small pancreatic*, consisting of several twigs, the *gastro-epiploica sinistra* near the termination of the vessel, the *vasa brevia* to the cardiac end of the stomach and the *splenic branches*, which enter the hilum of the spleen. The *splenic plexus*, a branch of the solar plexus, will be found accompanying this vessel.

The **splenic vein,** of large size, is also found in relation with the posterior surface of the pancreas passing from left to right, its *tributaries* corresponding in the main to the branches of the splenic artery but receiving also near its termination the *inferior mesenteric vein*, which

usually ascends behind the pancreas to reach the splenic vein. The splenic vein *terminates* by uniting with the superior mesenteric to form the portal vein (Fig 314).

The Solar Plexus.—This large sympathetic plexus, sometimes called the "abdominal brain," situated behind the stomach in front of

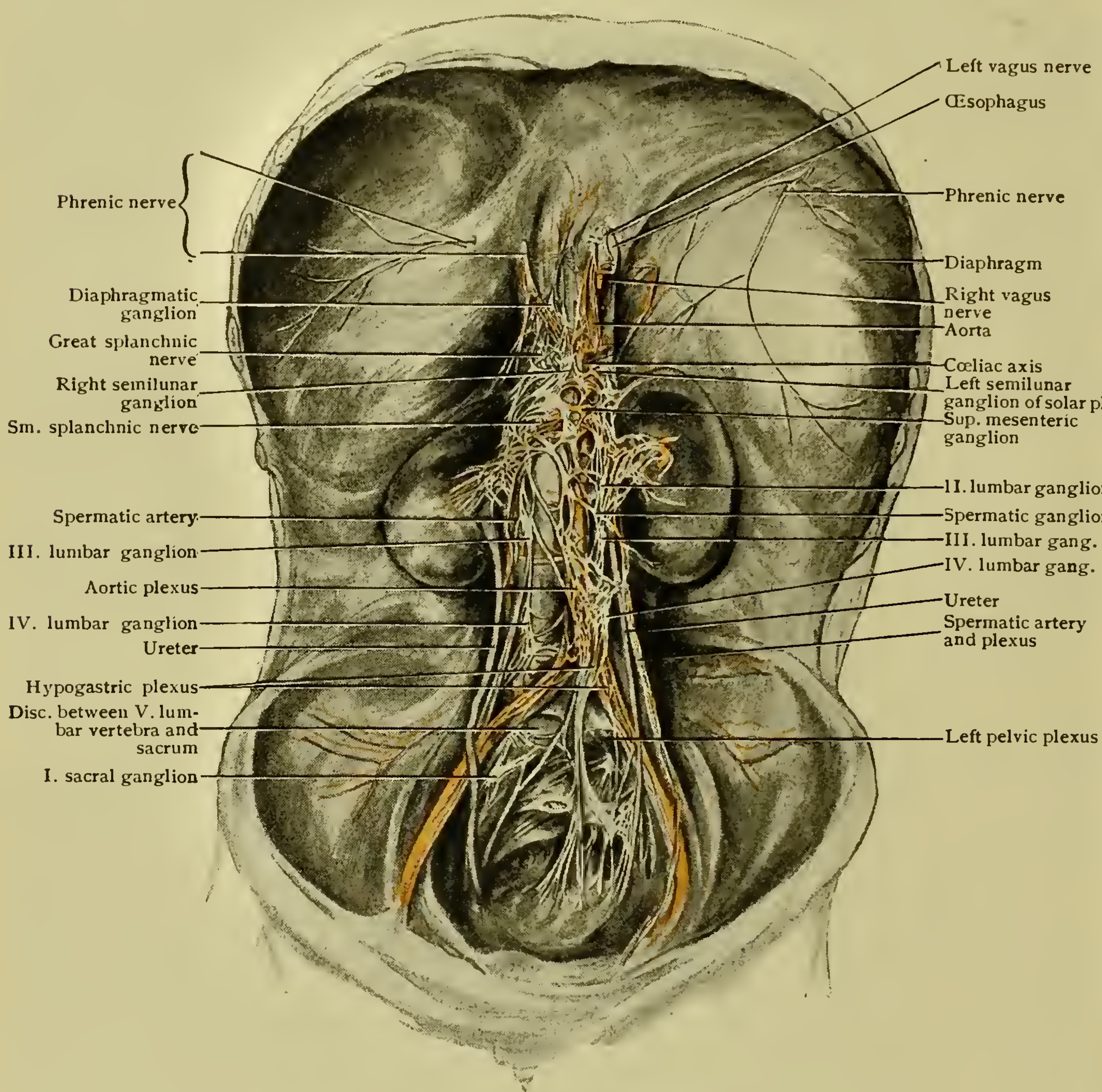

Fig. 322.—Dissection of abdominal sympathetic nerves, showing solar, hypogastric and secondary plexuses.

the crura of the diaphragm and surrounding the origin of the cœliac axis, should now be dissected (Fig. 321). It is said to consist of the two large **semilunar ganglia** situated one on either side of the aorta, connected with each other by interlacing cords composed of nerve-fibres; each of these ganglia in reality consists of many smaller ganglia connected by short bands of nerve-fibres, a fact which the dissector may demonstrate by careful dissection. The **branches** of the solar plexus correspond

in name and situation with the branches of the abdominal aorta with the exception that it has also an *aortic branch*, the *aortic plexus*, which descends in front of the aorta and which will be followed later. Most of these branches of the solar plexus have already been encountered in the dissection of the various arteries. They appear as two or three cords lying upon the vessel to which they belong, connected by numerous small strands.

THE SPLEEN.—The position of the spleen is in the left hypochondrium deeply placed opposite the ninth, tenth and eleventh ribs. The size of the spleen varies considerably, even in the same individual at different times. Its average weight is six ounces; its greatest horizontal

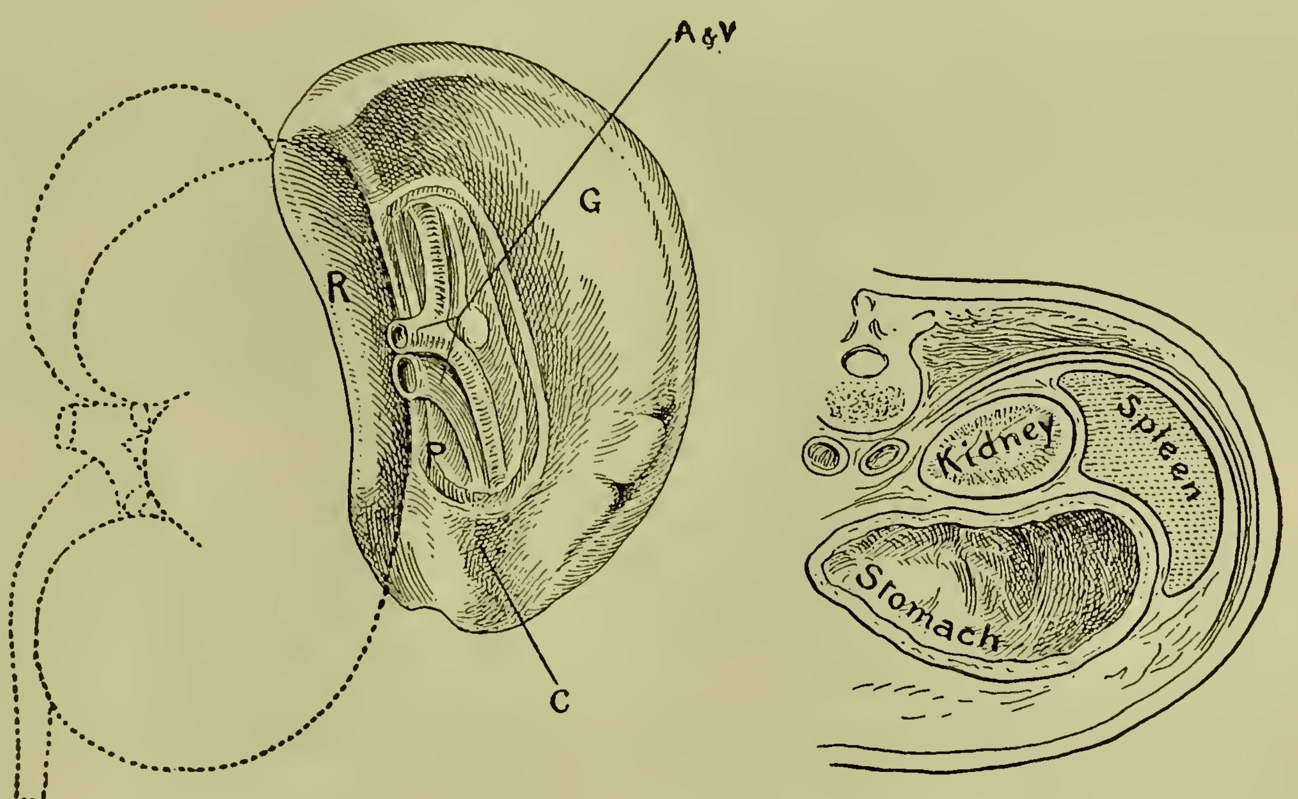

FIG. 323.—Spleen, anterior view and diagram of transverse section; R, renal; G, gastric; P, pancreatic; C, colic areas; A and V, artery and vein at hilum.

dimension, three inches, its vertical diameter, four to five inches. To appreciate its **relations** one must first take note of its **surfaces** and these again are best understood by comparing a transverse section (Fig. 323) with the organ itself. Such a section shows a large convex *phrenic surface* looking upward, backward, outward and forward, which is in contact with the diaphragm; an anterior or *gastric surface* looking forward and inward, concave and in contact with the cardiac extremity of the stomach, the tail of the pancreas, the splenic flexure of the colon and the mesocolon (Fig. 316); an *inner surface* in contact with the left adrenal and the left kidney. An inferior or *basal surface* is also described which, of course, would not be apparent in such a transverse section. The **borders** of the spleen (Fig. 323) are the *anterior border* which is usually *notched*, the depth and number of the notches varying, these being sometimes

palpable in the living subject if the abdominal wall is thin; a *posterior border*; an *inner border* separating the internal and the anterior surfaces; just in advance of the internal border is the *hilum* or aperture by which the vessels, nerves and lymphatics gain entrance to and exit from the organ.

The **peritoneal relations** of the spleen were indicated in tracing the peritoneum in horizontal section of the abdomen. They may be summarized by stating that the spleen is completely invested with peritoneum, that its inner border is connected with the left kidney and the diaphragm above the position of the kidney by the *lieno-renal ligament* or *phrenico-splenic omentum* between the layers of which the splenic artery reaches the organ, and that its hilum is connected with the cardia of the stomach by the *gastro-splenic omentum*. The relation of the *sustentaculum lienis* or *phrenico-colic ligament*, the shelf-like fold of the peritoneum which connects the splenic flexure of the colon with the parietal peritoneum in the neighborhood of the left tenth rib, should also be noted (Fig. 317).

The very free vascular supply of the spleen is related with its blood-forming function as well as with its variations in size. The spleen is sometimes *ruptured* as the result of external violence and from its relations to the peritoneum it will be seen that rupture would be attended with intra-peritoneal effusion of blood, the hemorrhage usually being quite copious.

The *splenic branches of the splenic artery* should now be followed into the hilum by clearing away the anterior layer of the phrenico-splenic omentum. The connection of the inner surface with the kidney should also be noted. The spleen may now be removed, the dissector passing his hand around the convex surface, thus demonstrating its freedom from connection with the abdominal wall, and reaching the left kidney with the tips of the fingers, demonstrating the connection of the spleen with this organ. The phrenico-splenic omentum should be cut, if possible, without detaching the peritoneum from the anterior surface of the kidney. The surfaces and borders of the organ may now be more minutely studied, the peritoneum may be stripped from the surface in order to expose the *fibrous capsule* and a section either in the transverse plane at the level of the hilum or in a coronal plane coinciding with the position of the hilum may be made.

THE REMOVAL OF THE LIVER.—The portal vein, the hepatic artery and the common bile-duct may be tied about three inches below the liver and these structures cut below the ligatures. Drawing the liver downward, the suspensory ligament should be cut close to the diaphragm; now depressing the organ still further, divide the upper layer of the coronary ligament and its lateral continuations, the lateral ligaments, pass two ligatures around the vena cava between the diaphragm and the liver and two below the liver and cut this vessel between each

pair of ligatures. Depressing the liver still more, cut the lower layers of the coronary and lateral ligaments and remove the organ from the body, placing it upon pads with the upper surface looking upward. Note again the lines of attachment of the peritoneum to the upper surface and its continuation from this median line of attachment toward either lateral border.

The Posterior Surface of the Liver.—This surface is divided into a right and a left portion by the posterior part of the longitudinal fissure, this portion of this fissure being known as the *fissure for the ductus venosus* because it accommodates that fetal vein as it makes its way from the portal vein to the inferior vena cava. Upon the left side of

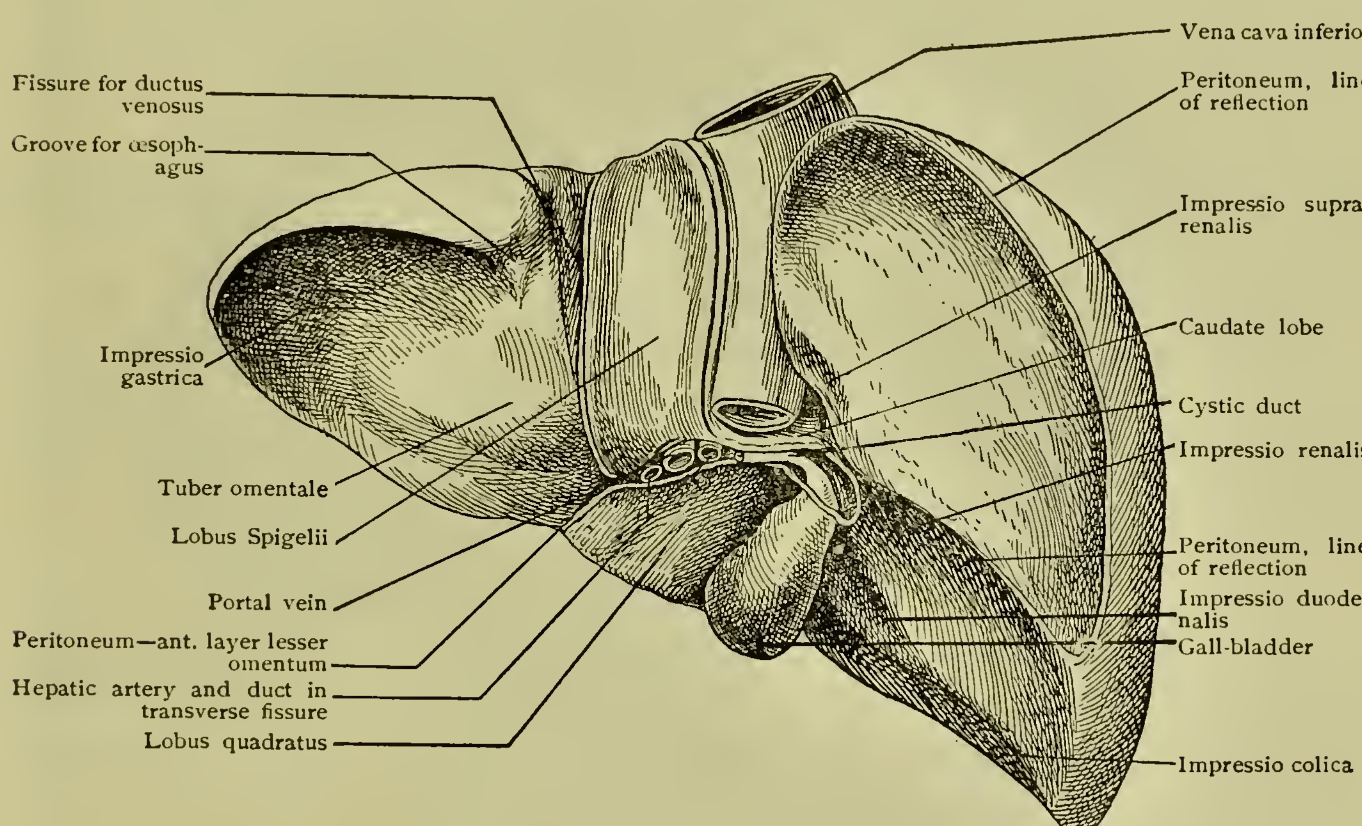

FIG. 324.—Liver, posterior and inferior surfaces. (His model.)

this fissure, near the upper border, is a small *notch* which accommodates the œsophagus, while the lower part of this surface becomes directly continuous with the omental tuberosity on the under surface. A few inches to the right side of the fissure for the ductus venosus is the *fissure for the inferior vena cava*, which vessel is deeply embedded in and almost surrounded by the liver structure. If this segment of the cava be forcibly drawn away from the liver the terminal portions of the *hepatic veins*, three or four in number, will be seen emerging from the liver to enter at once the inferior vena cava.

The *Spigelian lobe* is the surface included between the ductus venosus and the fissure for the vena cava. Upon the right side of the fissure for the vena cava, near the lower part of the posterior surface, will be seen the *suprarenal impression* for the accommodation of the right

suprarenal body (Fig. 324). The lines of attachment of the two layers of the coronary ligament should be particularly noted, these being near the upper and lower limits respectively of the posterior surface. All that part of the posterior surface of the organ which falls between the two layers of the coronary ligament is without peritoneal investment and comes into direct relation with the diaphragm.

Extravasation of blood or pus from the posterior surface of the liver would be non-peritoneal.

The **inferior surface of the liver** has been described but should be reviewed at this stage and will probably be best appreciated if the dissector will elevate the posterior surface, held toward the operator, to enable him to see the under surface from behind, that he may note again from this point of view the things already pointed out in relation with this surface of the organ.

The interior of the gall-bladder may be inspected by making an incision of proper size, the spirally arranged folds of mucous membrane near its orifice being especially noted.

The peritoneum may be stripped from at least a part of the surface of the liver, exposing the **fibrous capsule,** the **capsule of Glisson,** so intimately related to the structure of the organ since it is prolonged into the interior of the liver in repeatedly dividing fibrous processes which interlace to form the trabecular stroma.

THE POSTERIOR ABDOMINAL WALL.

The parietal peritoneum investing the posterior wall and the anterior surfaces of the retro-peritoneal organs in contact with it is to be removed in order to expose these organs and the wall itself. Its removal may be begun at the anterior surfaces of the kidneys.

The Kidneys.—The anterior surface of the right kidney is not entirely invested with peritoneum. To appreciate the relation of the peritoneum the relation of the anterior surface of the kidney itself must be taken into consideration. On the upper part of the anterior surface of the *right kidney* is an area, peritoneal, which is in relation with the renal fossa on the under surface of the right lobe of the liver (Fig. 325). Below this, along the inner border, is the *duodenal area* for the descending portion of the duodenum, which is non-peritoneal; upon the outer side of this is the *colic area* in contact with the upper part of the ascending colon which is usually non-peritoneal. Near the lower border between these two areas is the *mesocolic area*, a peritoneal surface covered by a part of the transverse mesocolon.

The **right suprarenal body,** situated just above the right kidney, presents an anterior peritoneal surface which is in contact with the posterior surface of the right lobe of the liver.

The peritoneal relations of the *left kidney* differ somewhat from those of the right. Approximately the upper one-third of the anterior surface of this organ is in contact with the posterior surface of the stomach (Fig. 325) and is known as the *gastric area;* it is peritoneal. Below this is the *pancreatic area*, a non-peritoneal region since the pancreas has no peritoneum on its posterior surface. Below the pancreatic area toward the left is the *colic area*, a non-peritoneal surface, while toward the right is a *peritoneal area* in contact with the termination of the duodenum.

The **left suprarenal body** presents an anterior peritoneal surface throughout the greater part of its extent which is in contact with the

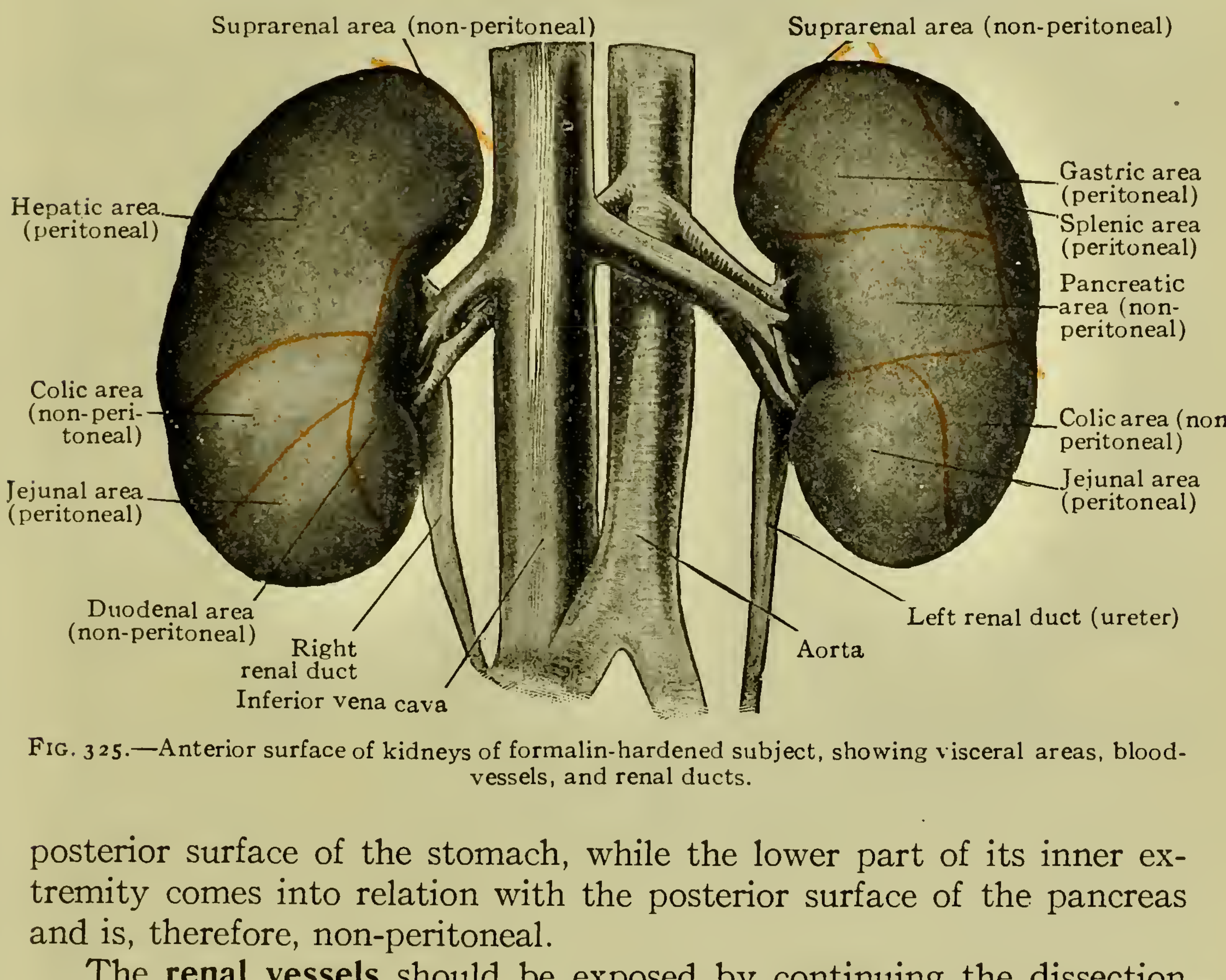

FIG. 325.—Anterior surface of kidneys of formalin-hardened subject, showing visceral areas, blood-vessels, and renal ducts.

posterior surface of the stomach, while the lower part of its inner extremity comes into relation with the posterior surface of the pancreas and is, therefore, non-peritoneal.

The **renal vessels** should be exposed by continuing the dissection of the peritoneum from the inner border of each kidney toward the mid-line. The **renal vein,** the most superficial of these vessels, will be encountered first and should be followed to its termination in the inferior vena cava. It will be noted that the left renal vein is longer than the right and that it receives as a *tributary* the left spermatic vein in the male and the left ovarian vein in the female. The **renal artery,** a branch of the abdominal aorta, lies posterior to the vein and upon being denuded of peritoneum presents upon its surface the renal plexus of the sympathetic, a branch of the solar plexus which also receives the renal

splanchnic nerve from the twelfth thoracic ganglion of the sympathetic (Fig. 322). This plexus includes the *renal ganglion* situated usually on the front of the artery. The renal artery sometimes gives off a *suprarenal branch* to the suprarenal body when this branch does not arise directly from the aorta.

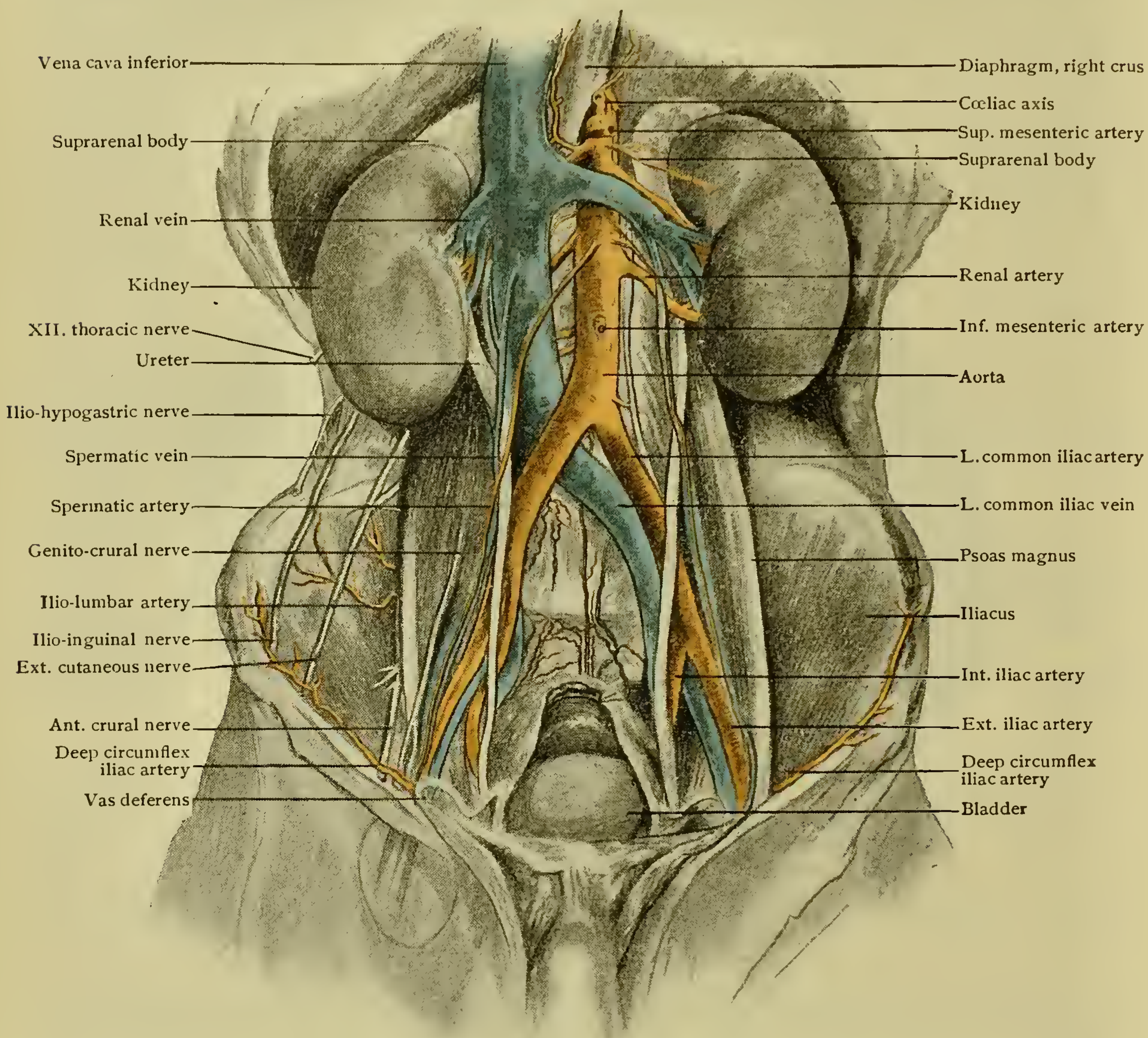

FIG. 326.—Dissection of posterior abdominal wall. The left spermatic vein is seen to terminate in the left renal vein. The rectum, its upper end cut and tied, is seen behind the bladder.

The removal of the peritoneum from the posterior abdominal wall should be completed by cautiously raising the membrane, first from the aorta and vena cava, then from the iliac vessels and remaining regions, using the handle of the knife and occasionally the blade to free its deep surface. The looseness of the *subserous areolar tissue* (p. 615) allows this to be accomplished with comparative ease. The underlying nerves and other structures are to be safe-guarded: in front of the aorta, the *aortic plexus;* over the vena cava, the *right spermatic artery*

and *vein;* to the right of the cava, the *right ureter;* to the left of the aorta, the *left ureter* and the *left spermatic artery* and *vein;* in the iliac fossa, the *iliac vessels* and the *nerves of the lumbar plexus;* to the outer side of each kidney, the *twelfth thoracic*, *ilio-hypogastric* and *ilio-inguinal* nerves.

The Ureter.—The ureter leaves the kidney behind the renal artery and vein, passing obliquely downward and inward for a short distance and then directly downward (Fig. 326). It originates in the dilatation, the *pelvis of the kidney* or of the *ureter*, which lies in a cavity within the kidney known as the *sinus*, and emerges through the orifice of the sinus, the *hilum*. The renal artery and vein should also be traced between the lips of the hilum to their entrance into and exit from the sinus respectively. Slightly displacing the vessels on the right side and also the descending part of the duodenum if this has not been removed, the *right ureter* will be exposed (Fig. 326).

The **abdominal stage** of the ureter includes that part of it between the hilum of the kidney and the brim of the pelvis, the duct obliquely crossing the front surface of the psoas muscle and the genito-crural nerve and being crossed obliquely by the spermatic (or ovarian) artery. A constriction, the *upper isthmus*, will be seen at some point within three and a half inches of the hilum of the kidney, and a fusiform dilatation, the *chief spindle*, followed by a second constriction, the *lower isthmus*, at the pelvic brim, where the duct will be observed to enter the pelvis by crossing either the common iliac artery and vein or the external iliac vessels. The ureter lies close to the right side of the vena cava inferior. If the *left ureter* be now similarly exposed, it will be seen to lie to the left of the aorta, to be covered at its beginning in some cases by the pancreas, and to pass behind the attachment of the meso-sigmoid below (Fig. 326).

The **pelvic** and **vesical stages** of the course of the ureter, which differ in the two sexes, will be considered in connection with the pelvic cavity (p. 688).

The Abdominal Aorta.—The abdominal aorta, a continuation of the thoracic aorta, **begins** at the aortic opening of the diaphragm opposite the lower border of the last thoracic vertebra and **terminates** at the level of the fourth lumbar vertebra by dividing into the two common iliac arteries. Its course is a little to the left of the mid-line, its place of bifurcation being indicated by a point upon the surface of the abdominal wall slightly below and to the left of the umbilicus on the level of the highest points of the crests of the ilia (Fig. 326).

The **relations** of the abdominal aorta are *behind*, the upper four lumbar vertebræ and the left lumbar veins; on the *right side*, the inferior vena cava separated above by the right crus of the diaphragm, while the thoracic duct, the receptaculum chyli and the vena azygos major are on the right side and partly behind; on the *left*, the left crus

of the diaphragm, the fourth part of the duodenum, the left ureter and the left spermatic (or ovarian) artery and vein; *in front*, the aortic plexus and, from above downward, the pancreas, the transverse part of the duodenum, and the left renal vein, while in less intimate relation are the stomach, the transverse colon and the coils of the jejunum and ileum.

The **branches** are (a) the **visceral branches,** including the *inferior phrenic arteries*, the *cœliac axis*, the *superior mesenteric*, the *inferior mesenteric*, the two *spermatic* (or the two *ovarian*) *arteries*, the two *suprarenal* and the two *renal arteries;* (b) the **parietal branches,** the four pairs of *lumbar* arteries, in series with the intercostal branches of the thoracic aorta, and the *sacra media*, which arises from the point of bifurcation of the aorta and continues downward along the mid-line of the sacrum representing the caudal aorta of most vertebrates.

The **aortic plexus of the sympathetic** having been exposed by the removal of the peritoneum from the front of the aorta (Fig. 322), it should be dissected, its continuity above with the solar plexus and below with the hypogastric plexus established and its reception of filaments from the lumbar sympathetic ganglia demonstrated. It will be seen to consist of two chief cords connected by rather irregular interlacing bands of fibres and to give off the *inferior mesenteric plexus* and filaments to the renal plexus.

The **solar plexus,** previously dissected, will be seen, in the dissection of the branches of the aorta, to contribute a plexus to each branch of the abdominal aorta, and to give off the aortic plexus in addition to these branches.

The visceral branches of the aorta have been dissected except the inferior phrenic and the spermatic arteries.

The **inferior phrenic arteries** (Fig. 308) should be traced from their origin just below the diaphragm upward and outward to their distribution to the diaphragm and, by their *internal branches*, to the œsophagus around which tube they anastomose. Their *superior suprarenal branches* should be traced to the suprarenal bodies.

The **spermatic arteries** should be followed from their points of origin downward and outward, the *spermatic nerve-plexuses* accompanying them being noted as receiving filaments from the renal plexuses; the **spermatic veins** should also receive due attention. The lower parts of these vessels have been traced (pp. 628 and 671).

The **lumbar arteries** (four pairs) should be followed from their origin for a short distance; they cannot be completely dissected at present. They pass outward beneath the gangliated cord of the sympathetic, those of the right side going also beneath the vena cava. Each lumbar artery gives off soon after its origin, and beneath the psoas, a **dorsal branch,** which passes toward the dorsal surface of the body and gives

off a *spinal branch*, this entering the spinal canal to assist in the supply of the spinal column and the spinal cord and its membranes (p. 591), and a *muscular branch*, distributed to the muscles of the back. The continuation of the artery is traceable across the posterior abdominal wall behind the psoas and the lumbar plexus to be distributed to the muscles of the anterior and lateral parts of this wall, assisting the lower intercostal arteries, the internal mammary and the deep circumflex iliac in supplying these structures. The two upper arteries pass behind the quadratus lumborum, the two lower in front of this muscle (Fig. 363).

The abdominal aorta is sometimes the seat of *aneurism*. In thin subjects the pulsations of the abdominal aorta may be readily felt by palpation of the anterior abdominal wall with the hand. A tourniquet is sometimes applied to the abdominal aorta for the purpose of controlling hemorrhage in hip-joint operations, or for the treatment of aneurism near the bifurcation of the aorta, the pad of the tourniquet being applied slightly to the left of the umbilicus, the patient being placed upon his right side to get the coils of the small intestine as much out of the way as possible.

The Inferior Vena Cava.—The **origin** of the inferior vena cava is at the level of the fourth disc or the fifth lumbar vertebra by the confluence of the right and left common iliac veins. Its **termination** is in the posterior inferior angle of the right auricle of the heart immediately after piercing the diaphragm. The **relations** of the inferior cava are, in the upper part of its course, the posterior surface of the liver, the cava being embedded within the fissure for the cava; upon the *left side*, the abdominal aorta, the thoracic duct, the receptaculum chyli and the vena azygos major; upon the *right side*, the right ureter, the right kidney, and in the upper part of its course the right sympathetic nerve; *in front*, the right renal artery, the descending duodenum, the head of the pancreas, the transverse duodenum, while the right spermatic artery obliquely crosses the cava from within outward. The **tributaries** of this trunk, in addition to the two common iliac veins, are the *lumbar veins*, the *right spermatic* or *right ovarian vein*, the *renal* and *suprarenal veins* and the *hepatic veins* (Fig. 364).

The Vena Azygos (Fig. 364).—The azygos vein or *vena azygos major* should be sought at its **origin**, just below the diaphragm, as the upward continuation of the right ascending lumbar vein. It is partly concealed by the inferior vena cava, to the inner side of which it lies and which must be displaced outward to expose it. It is also in close relation with the aorta and with the thoracic duct, the latter lying between it and the aorta and being in danger of injury unless the dissector exercise care in isolating the vein. The vein should be traced to either the aortic opening of the diaphragm, through which it usually passes to enter the thorax, or to the right crus, which it sometimes pierces (*vide* p. 748).

The Vena Hemiazygos.—The hemiazygos vein or *vena azygos minor inferior*, **originating** from the left ascending lumbar vein, should be

found on the left side of the aorta, just below the diaphragm, and traced to the left crus of that muscle through which it passes to reach the thorax (p. 748).

The Thoracic Duct (Fig. 366).—This vessel is to be exposed by displacing the vena cava and the aorta from the mid-line, the duct being partly concealed by the aorta and having the vena azygos on its right side. The duct may be difficult to discover but may usually be found if its relations as just indicated be borne in mind. It begins in front of the second lumbar vertebra by the union of the **right** and **left lumbar trunks,** which drain the lumbar lymph-nodes, and at once expands into a fusiform enlargement, the **receptaculum chyli** (or cistern of Pecquet). The cistern is from two to three inches in length and is joined on the left side by the **common intestinal lymph=trunk** and farther up by two vessels from the lower thoracic nodes. The duct should be traced to the aortic opening of the diaphragm which transmits it to the thoracic cavity (p. 748).

The Splanchnic Nerves.—The **great splanchnic nerve** (p. 751) should be found piercing the crus of the diaphragm and going to the upper end of the semilunar ganglion of the solar plexus; the **small splanchnic nerve** should be found in close proximity to the latter, since it also pierces the crus and passes to the lower part of the semilunar ganglion.

The **least** or **renal splanchnic** will be found more laterally placed and if recognized at its emergence through the diaphragm may be traced to the renal plexus. The suprarenal body must be displaced outward to some extent to facilitate access to the nerve.

The Kidneys.—In addition to being partially covered in front by the parietal peritoneum, the anterior surfaces of the kidneys are related with the anterior lamella of the **renal fascia** (perirenal fascia), a layer of fatty tissue, the *perirenal fat*, being between this fascia and the parietal peritoneum. The anterior layer of the renal fascia of one side is continuous with that of the other side in front of the aorta and cava. The posterior lamella of the renal fascia, continuous externally with the anterior layer, passes behind the kidney and acquires attachment to the vertebræ. The renal fascia is a condensation of the subperitoneal tissue. By its deep surface it is connected with the fibrous capsule of the kidney by bands of connective tissue which pass through the fatty layer, the *perirenal fat*, between the renal fascia and the kidney. The posterior layer of the fascia is connected also with the transversalis fascia. If the kidney be elevated from its resting place this fat and fascia may be inspected.

Deficiency of the perirenal fat which may occur in emaciation of the body or in depressed states without special emaciation permits of a certain amount of movement of the kidney, the condition known as **movable kidney.** A variation of the relation of the kidney to the peritoneum whereby the organ instead of being retro-peritoneal has a sort of mesentery, is known as **floating kidney,** a congenital condition.

The kidneys should now be displaced forward and toward the midline, and the perirenal fat should be removed to expose the structures in relation with the posterior surface of the organ. Reference to Fig. 327 will show that along the mesial border of the posterior surface, the kidney is in relation with the psoas muscle, while farther outward it

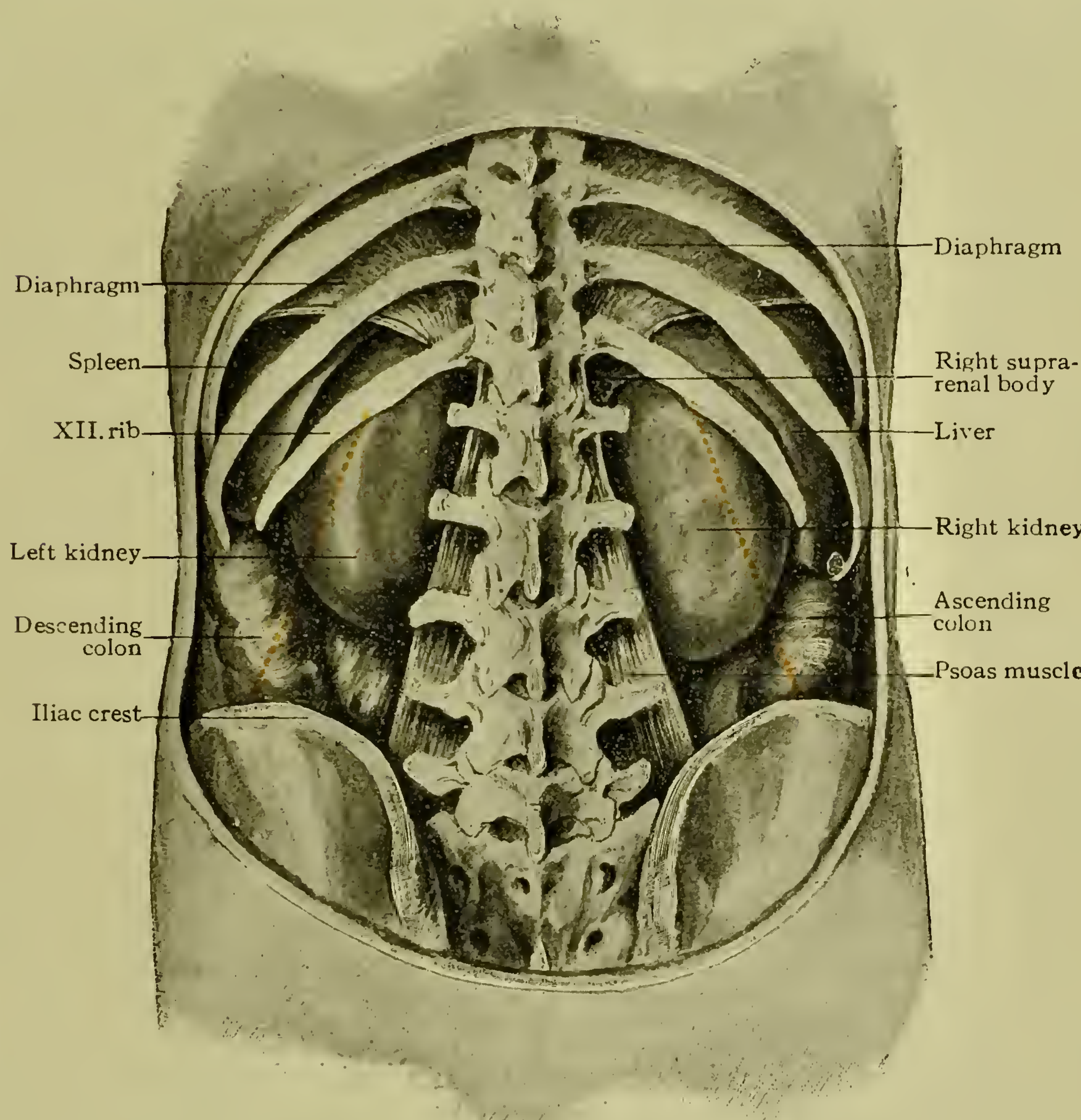

FIG. 327.—Posterior aspect of kidneys *in situ* in formalin subject; portion of posterior body-wall has been removed, as have been also parts of pleural sacs and diaphragm.

comes into relation with the quadratus lumborum and still farther outward with the posterior aponeurosis of the internal oblique; approximately the upper third of the posterior surface is in relation with the diaphragm, the pleura intervening between the diaphragm and the posterior wall of the body. The level to which the pleura descends varies, but usually the line of its lower limit crosses the twelfth rib.

It is evident from the relationships pointed out above that if the kidney is attacked through the loin for the various operations of *nephrotomy, nephrectomy* or *nephro-lithotomy*, care must be exercised to avoid trespassing upon the pleural cavity by making the incision too far upward.

The kidneys may now be removed from the body, for more detailed study, by severing each renal artery and vein. The *capsule* of the kidney may usually be stripped off from the organ rather readily. The *hilum* of the organ, the aperture which opens into the sinus, should be examined and the relations of the *ureter*, the *renal artery* and the *renal vein* noted.

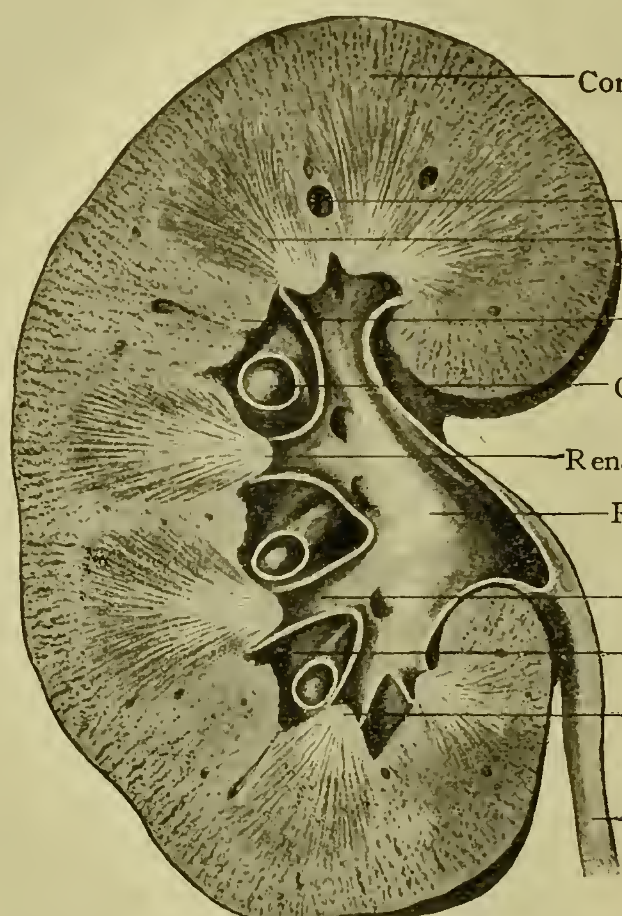

FIG. 328.—Longitudinal section of right kidney, showing relations of pelvis and its divisions to renal substance and to sinus.

The organ should be cut in the coronal plane just in front of the anterior lip of the hilum, the fingers being insinuated into the hilum in front of the other structures and after the fingers a knife-blade should be introduced and made to cut from within outward; this section will expose the **sinus** and its contents. The dissector will note the expansion of the ureter within the sinus to form the **pelvis** and the manner in which the **infundibula** and **calices,** or subdivisions of the pelvis, embrace the apices of the Malpighian pyramids (Fig. 328). The renal artery will be traced through the hilum into the sinus, its branches noted and the entrance of these branches into the kidney substance between the Malpighian pyramids, *i.e.*, into those portions of the kidney parenchyma known as the columns of Bertin. The tributaries of the renal vein will be noted emerging from the columns of Bertin at the same places and

converging to form the renal vein, which leaves the sinus through the hilum. Other occupants of the sinus are the *lymphatics* and the *nerves.*

The **suprarenal bodies** should also be cut, exposing the soft interior of the organ, the central medullary matter being of such consistence as to have suggested the name of *capsule* for this organ.

The Lumbar Ganglia of the Sympathetic.—The lumbar portion of the gangliated cord of the sympathetic (Fig. 329) includes usually four ganglia, though there may be less or as many as eight. They are made accessible upon the removal of the kidneys and the removal or displacement of the aorta and vena cava. They lie on the antero-lateral aspects of the vertebral bodies and are sometimes quite effectually masked by a covering of fascia. Locating the first ganglion, the *association cord* connecting it with the last thoracic ganglion should be sought at its emergence through the diaphragm and the ganglia should then be successively exposed.

The **somatic branches,** including the *white* and the *gray rami communicantes*, may be followed outward beneath the fibrous arches of the psoas muscle in company with the lumbar arteries, which latter are behind the ganglia. After the dissection of the psoas, the rami may be traced to their union with the corresponding lumbar nerves.

The **visceral branches** pass inward to join the aortic and hypogastric plexuses—by which route they reach the pelvic viscera—and to supply the bones and ligaments of the spine.

Psoas Magnus (Fig. 111).—**Origin,** the sides of the bodies and of the vertebral discs of the last thoracic and of all the lumbar vertebræ and the transverse processes of the lumbar vertebræ; **insertion,** the lesser trochanter of the femur by a tendon; **nerve=supply,** the second, third and fourth lumbar nerves through the lumbar plexus; **action,** flexion and eversion of the femur and the steadying of the trunk upon the femur when the latter is fixed.

The muscle is enveloped in a fascia, the *psoas fascia.* It is crossed at its upper part by a tendinous arch, the *internal arcuate ligament* (Fig. 111) with which the psoas fascia is continuous. Those portions of the muscle which arise from the vertebral bodies do so by a series of arches bridging over the central portions of the bodies under which arches pass the lumbar arteries and the somatic branches of the lumbar ganglia. Embedded within the substance of the muscle is the lumbar plexus, the principal trunks of which emerge from the outer side of the muscle. The fascia should now be removed from the muscle, its attachment to the lumbar vertebræ being noted and the dissector detecting and guarding the *obturator nerve* as it emerges from the inner aspect of the muscle, the *genito-crural nerve*, emerging from its anterior aspect, the *external cutaneous*, the *ilio-inguinal* and the *ilio-hypogastric nerves* emerging from the outer surface and the *anterior crural* coming from the posterior surface and passing downward and outward (Fig. 326).

A **psoas abscess** is a collection of pus within the fascial sheath of the psoas resulting from caries (ulceration) of the lower thoracic or the lumbar vertebræ. Such a collection of pus most commonly follows the sheath of the psoas into the thigh and points upon the anterior surface of the thigh at the outer side of the femoral vessels. It may, however, reach the fascial sheath of the iliacus muscle and make its way over the crest of the ilium into the gluteal region, or it may travel into the pelvis and find its way into the bladder.

Psoas Parvus.—**Origin,** the last thoracic and the first lumbar vertebra; **insertion,** the iliac fascia and the pectineal eminence; **nerve-supply,** the first lumbar nerve; **action,** the tensor of the iliac fascia. This small muscle (Fig. 111), frequently absent on one or both sides of the body, should be dissected, if present, and may then be removed.

Quadratus Lumborum.—The *posterior layer:* **Origin,** the posterior part of the crest of the ilium and the ilio-lumbar ligament; **insertion,** the inner part of the lower border of the twelfth rib and by pointed processes into the tips of the transverse processes of the upper four lumbar vertebræ. The *anterior layer:* **Origin,** the posterior part of the crest of the ilium and the transverse processes of the lower four lumbar vertebræ; **insertion,** the lower border of the twelfth rib. **Nerve-supply,** the lumbar plexus. **Action,** to pull down the last rib; to cause lateral flexion of the spine (Figs. 330 and 279).

This muscle is crossed above by the *external arcuate ligament* (Fig. 111) and is covered anteriorly by the anterior lamella of the lumbar fascia (Fig. 278). In removing the lumbar fascia the ilio-inguinal and ilio-hypogastric nerves will be encountered crossing the muscle obliquely from within outward (Fig. 329).

The Lumbar Plexus.—This plexus is formed by the dorsi-lumbar cord descending from the twelfth thoracic nerve and by the anterior divisions of the first, second, third and a part of the fourth lumbar nerves (Fig. 329). It can only be exposed by removing the psoas magnus muscle. This is done with greatest safety to the nerves by following consecutively those trunks which have been found to emerge from the muscle, cutting away such portion of the muscle substance as may be necessary to permit of their being traced. The dissector may begin with the obturator nerve on the inner side of the muscle and attack next the genito-crural on the front and then those nerves which emerge from the outer side and from the posterior aspect of the muscle.

The **branches** of the plexus now exposed are the *muscular, ilio-hypogastric, ilio-inguinal, genito-crural, external cutaneous, obturator, accessory obturator* and *anterior crural* or *femoral.* In tracing such of these nerves as lie beneath the iliac fascia, that fascia should be incised to the necessary extent.

The **muscular branches** supply the psoas magnus and parvus and the quadratus lumborum.

The **ilio-inguinal** and **ilio-hypogastric** arise from the first and second lumbar nerves and contain some fibres derived from the last thoracic nerve; their distribution has been followed in the dissection of the anterior abdominal wall.

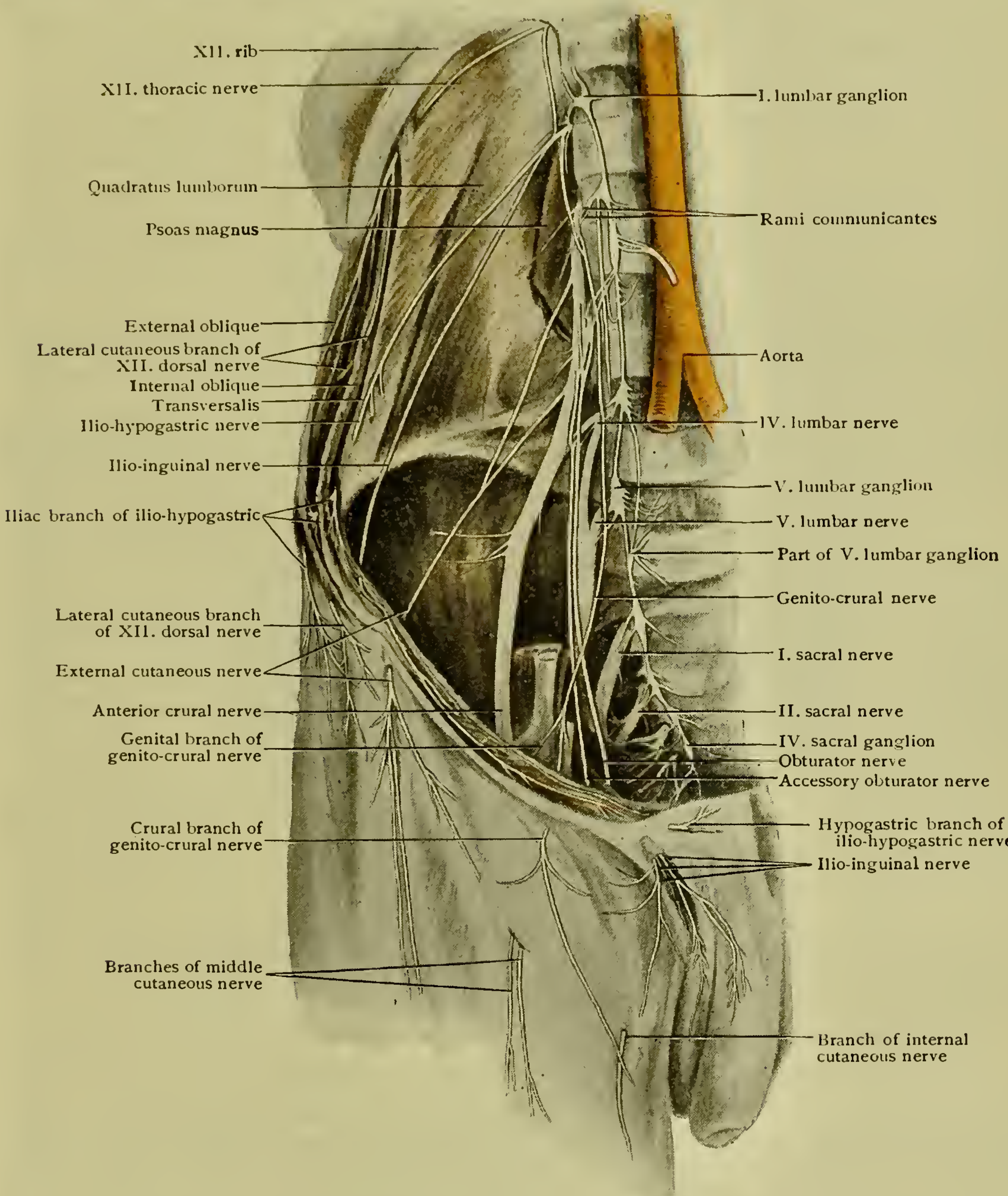

FIG. 329.—Deep dissection, showing nerves arising from lumbar plexus and lower part of sympathetic gangliated cord.

The **external cutaneous nerve,** coming from the second and third nerves, passes downward and outward beneath the iliac fascia to the anterior superior spine of the ilium, near which it leaves the abdominal cavity by passing under Poupart's ligament (p. 197).

The **genito-crural nerve,** arising from the first and second lumbar, emerges from the anterior aspect of the psoas and passing downward upon its surface divides into the *crural branch*, which enters the thigh within the sheath of the femoral vessels, lying upon the anterior surface of the femoral artery (p. 198) and the *genital branch.* The latter, diverging outward, enters the internal abdominal ring to accompany the spermatic cord and to supply the cremaster muscle (Fig. 329).

The **obturator nerve** arising from the second, third and fourth lumbar nerves and passing downward and somewhat inward into the pelvic cavity, should be traced along the upper part of the lateral wall of the pelvis, the peritoneum being displaced to a sufficient extent, to the upper part of the thyroid foramen through which it makes its exit from the pelvis into the thigh (p. 218).

The **accessory obturator nerve** (Fig. 109), not always present, arising from the third and fourth lumbar nerves, passes downward beneath the psoas muscle and the iliac fascia and enters the thigh under Poupart's ligament and under cover of the outer border of the pectineus muscle, supplying the pectineus and giving an articular branch to the hip-joint.

The **anterior crural nerve** arising from the first, second, third, and fourth lumbar nerves, after traversing the substance of the psoas muscle, passes downward between the psoas and iliacus beneath the iliac fascia to leave the abdomen under Poupart's ligament slightly external to the femoral artery; its **branches** within the abdomen are *muscular branches* to the psoas and to the iliacus; the *branches* given off in the thigh are set forth on page 204.

Iliacus.—**Origin,** the upper two-thirds of the iliac fossa and the corresponding part of the crest of the ilium; **insertion,** the outer side of the tendon of the psoas, the lesser trochanter of the femur and the surface of bone immediately below it; **nerve-supply,** the second, third and fourth lumbar nerves through the anterior crural; **action,** to aid in flexion and eversion of the thigh. This muscle and the psoas magnus are often regarded as one, the *ilio-psoas* (Fig. 111).

The **iliac fascia** which covers this muscle is attached to the crest of the ilium and to the brim of the true pelvis; below it is continued into the thigh as the posterior wall of the sheath of the femoral vessels. External to the femoral vessels it blends with the transversalis fascia along the line of Poupart's ligament. At the upper part of the iliac fossa the iliac branches of the ilio-lumbar artery from the internal iliac will be seen entering the muscle after having passed beneath the psoas (Fig. 326).

An *iliac abscess*, or a collection of pus within the sheath of the iliacus, results usually from an extension of the pus of a psoas abscess, there being no distinct septum between the psoas and iliacus sheaths.

The posterior abdominal wall having been denuded the lumbar arteries may now be followed (p. 672).

THE DIAPHRAGM (Fig. 330).—**Origin,** by the *right crus* or *pillar* from the bodies of the first, second and third lumbar vertebræ and by the *left crus* from the bodies of the first and second lumbar vertebræ; the internal and the external arcuate ligament; the inner surfaces of the lower six ribs and their costal cartilages interdigitating with the transversalis, and by a few fibres from the ensiform. **Nerve=supply,** the

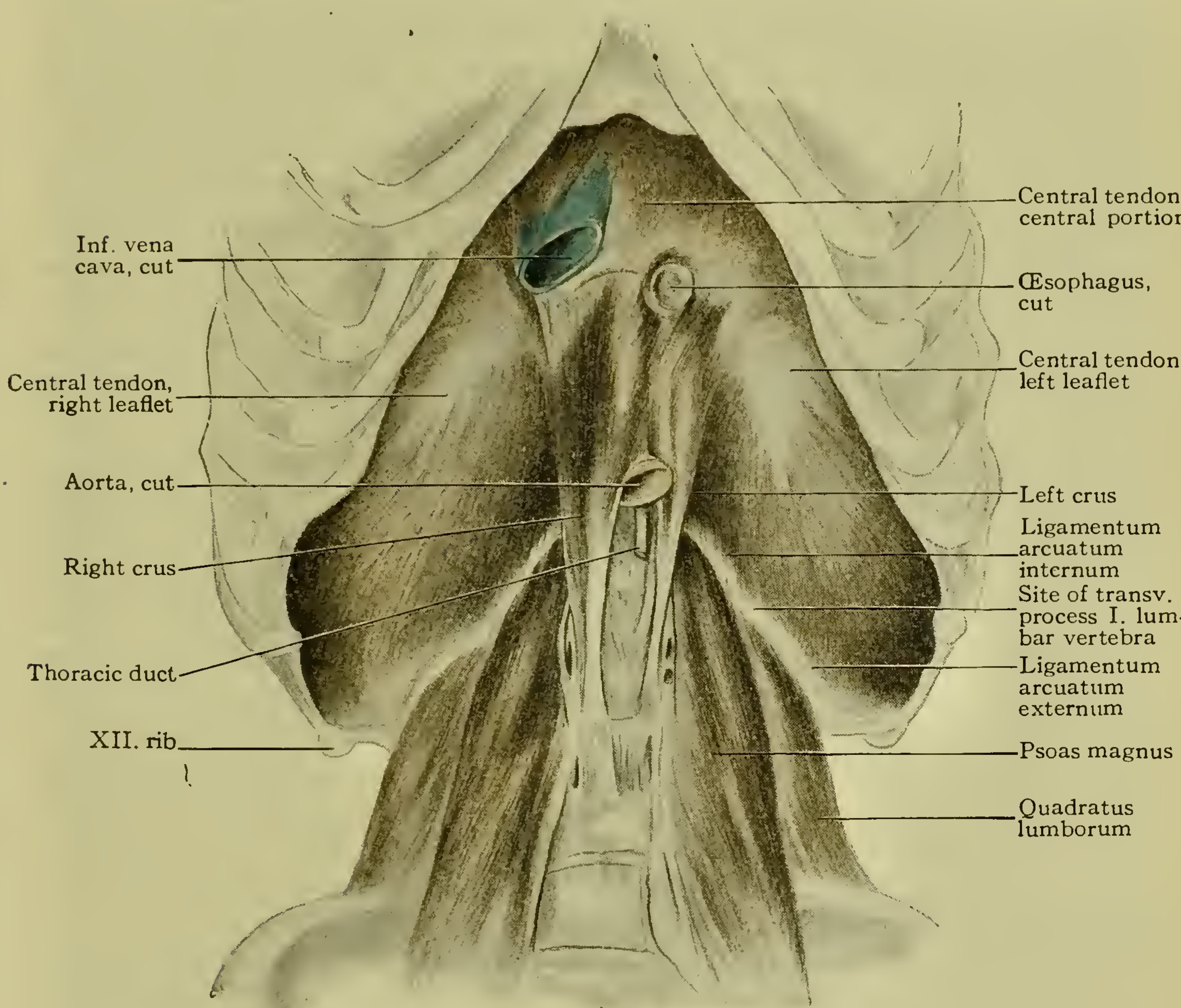

FIG. 330.—Dissection of the diaphragm, showing its inferior surface.

right and left phrenic nerves which pierce the muscle and are distributed to its under surface; **action,** to enlarge the thoracic cavity in the vertical direction, acting as the chief muscle of inspiration.

The crura should first be cleaned and then the part of the muscle arising from the arcuate ligaments. The **internal arcuate ligament** is a tendinous band passing from the side of the body of the first or second lumbar vertebra to the tip of the transverse process of the first or second, and arching across the surface of the psoas muscle (Fig. 330). The **ligamentum arcuatum externum,** a similar tendinous band, arches from

the tip of the transverse process of the first or second lumbar vertebra to the lower border of the twelfth rib, crossing the anterior surface of the quadratus lumborum (Fig. 330).

The **diaphragmatic fascia,** which invests the under surface of the diaphragm, is a dense membrane so closely adherent to the muscle that its removal is extremely difficult. This is particularly so if the diaphragm has been punctured in the removal of the abdominal viscera or if air has been admitted to the thoracic cavity in any other way. To facilitate the removal of this fascia the lower aperture of the thorax should be widened as much as possible by pulling the lateral margins of the costal angle apart and maintaining them in that position. It is assumed that the parietal peritoneum that covers the diaphragmatic fascia has been already removed. Beginning the denudation at the crura, the **aortic opening** will be encountered, which is rather behind the diaphragm than within it, the muscular bundles arising from the crura interlacing in front of this aperture. The aortic opening transmits the left sympathetic nerve as well as the aorta, and usually the vena azygos major and thoracic duct. Continuing the denudation upward, the **œsophageal opening** will be found somewhat to the left, transmitting the œsophagus and the right and left pneumogastric nerves. The **left phrenic nerve** (Fig. 322) pierces the diaphragm to the left and in front of the œsophageal opening, communicating usually with some branches of the sympathetic and presenting the *diaphragmatic ganglion.* The **caval opening** (quadrate aperture) of the diaphragm, the highest of the openings of the muscle and situated somewhat to the right of the midline, will be easily found and a little to its right the *right phrenic nerve* may be detected with its *diaphragmatic ganglion.* Having completed the removal of the fascia, the **cordiform tendon** of the diaphragm will be exposed and the convergence of the muscular fibres from various parts of the circumference of the inferior aperture of the thorax toward the margins of this tendon will be noted.

The **hiatus diaphragmaticus** is an aperture not infrequently found in the lower part of the muscle to the left of the left crus. At this aperture the pleura lining the chest cavity comes into relation with the peritoneum; this opening is sometimes the seat of *diaphragmatic hernia.*

The Common Iliac Vessels (Fig. 326).—The parietal peritoneum having been removed from the common iliac vessels, their surfaces should be freed from any loose subserous tissue that may remain, the dissector safe-guarding the *ureters*, the *hypogastric plexus* in the form of fibrous bands passing from the front of the aorta and over these vessels into the pelvic cavity, and the *fibres* from the lower lumbar ganglia that pass to the hypogastic plexus.

The Right Common Iliac Artery (Fig. 326).—This vessel, one of the terminal branches of the abdominal aorta in the human subject, may

now be followed in its course downward for the approximately two inches of its length, to its **termination,** opposite the sacro-iliac articulation in its *terminal branches*, the internal and external iliac arteries. It should be gently separated by the scalpel handle, on the outer side, from the right common iliac vein and the vena cava above and the psoas magnus below, and in the same way should be raised slightly from the subjacent common iliac veins.

The Left Common Iliac Artery.—What was said above of the **origin, course** and **termination** of the right common iliac artery applies also to the left one. The left vessel, however, is shorter than the right and in addition to being crossed by the ureter and certain sympathetic nerves, is crossed by the line of attachment of the meso-sigmoid and by the superior hemorrhoidal artery. Furthermore, it will be seen to be in relation on its outer side with the psoas muscle, while the left common iliac vein lies partly beneath and partly to the inner side of the artery, and the latter rests upon the bodies of the fourth and fifth lumbar vertebræ.

The **relations** of the common iliacs have thus been sufficiently indicated.

The **branches,** aside from the *terminal branches*, are *small trunks* given to the ureters, the psoas and the peritoneum; occasionally they give rise to an *accessory renal* or to the *ilio-lumbar artery*.

The **surface line** of the common iliac artery is drawn from a point a half inch to the left of the mid-line of the anterior abdominal wall on the level of the highest parts of the iliac crests, to a point midway between the anterior superior spine of the ilium and the spine of the pubis, the termination of this vessel and the beginning of the external iliac artery being indicated by the intersection of this line by one connecting the two anterior superior iliac spines.

To **ligate** the common iliac artery for *aneurism* or *hemorrhage*, it is evident that it may be reached either by a median abdominal incision opening the peritoneal cavity, or by the extraperitoneal route, the parietal peritoneum being stripped up from the iliac fossa through an incision in the flank or along Poupart's ligament.

The Common Iliac Veins (Fig. 326).—These vessels **originate** by the union of the internal and external iliac veins and **terminate** by uniting with each other to form the vena cava inferior. It will be seen that the left vein is longer and that their **tributaries** are the *ilio-lumbar* and sometimes the *lateral sacral veins*, the left also receiving the *middle sacral vein*.

The **relations** of the veins to the arteries have been seen in the dissection of the latter. If either vein be cautiously elevated, it will be found to be in relation behind with the fifth lumbar vertebra and the association cord connecting the last lumbar with the first sacral ganglion and sometimes with the last lumbar ganglion itself.

The External Iliac Artery (Fig. 326).—The external iliac artery, **originating** at the sacro-iliac articulation as one of the terminal branches of the common iliac, **terminates** beneath the middle of Poupart's ligament where it becomes the femoral artery. In clearing its surface of the subserous tissue, **Abernethy's fascia,** which covers it, the ovarian vessels in the female and sometimes the ureter will be found crossing it near its origin, while farther down the vas deferens in the male or the round ligament in the female will be found passing transversely over it. Still lower, it is crossed obliquely by the genital branch of the genito-crural nerve and transversely by the deep circumflex iliac vein. Lymph-nodes will be found on the anterior and also along the inner surface of the vessel. The artery should be gently separated by the blunt dissector from the external iliac vein on the inner side, which latter, in the case of the right vessels, gets behind the artery above, and from the psoas on the outer side. If the artery be now elevated it will be seen to rest upon the psoas muscle near Poupart's ligament, but above this region, upon the outer border of the vein.

The **relations** of the artery are as just detailed.

The **surface line** is indicated in connection with that of the common iliac artery.

The **branches** are some small *muscular twigs*, the *deep epigastric* and the *deep circumflex iliac*.

The **deep epigastric artery** should be traced from its origin near Poupart's ligament, downward and inward and then upward to the abdominal wall. Its further course has been followed (p. 612). Its **branches** are the *cremasteric*, already dissected (p. 614), the *pubic*, *muscular* and *cutaneous*. The **pubic branch** may be followed over the posterior surface of the pubic bone and its anastomosis with the pubic branch of the obturator noted.

The **deep circumflex iliac artery** (Fig. 326) has been encountered and dissected (p. 607).

The external iliac artery may require **ligation** for *aneurism*. What was said (p. 683) of the methods of approaching the common iliac is equally applicable in this case except as to certain modifications in the positions of the external incisions, the incision for the transperitoneal operation being made through the linea semilunaris instead of through the linea alba.

THE MALE PELVIS.

Before attempting the dissection of the pelvic cavity, it will be well for the dissector to study the bony pelvis, noting its boundaries and the bones which enter into its composition, as well as its form. The pelvis is **bounded** posteriorly by the sacrum and coccyx; laterally by the ischium and a small part of the ilium; anteriorly by the pubis and to some extent by the ramus of the ischium. Its **superior aperture,** the **superior**

strait, is bounded in front by the symphysis pubis, from which diverge on either side the ilio-pectineal lines separating the true pelvis from the false pelvis; postero-laterally by the sacro-iliac joints and posteriorly by the promontory of the sacrum or the sacro-vertebral angle. The **inferior aperture** or **outlet** of the pelvis is bounded in front by the pubic arch, that is, the converging rami of the pubes and the symphysis pubis; laterally, by the rami and tuberosities of the ischia; postero-laterally, by the great sacro-sciatic ligaments; posteriorly, by the tip of the coccyx. This aperture is closed from behind forward by the coccygeus and levator ani muscles and the triangular ligament, structures already encountered in the dissection of the perineum. The chief *pelvic viscera* are the sigmoid colon when undistended, the rectum, the bladder and the prostate gland.

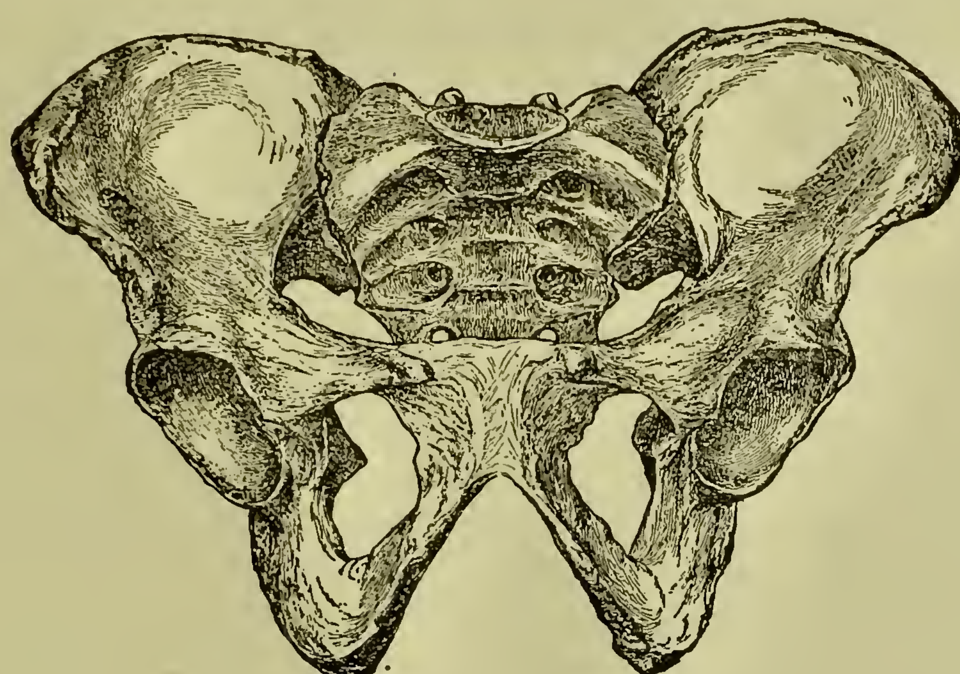

FIG. 331.—Male pelvis from before.

Before disturbing the relations of the pelvic viscera, the latter should be subjected to a general survey. The **rectum** is indicated by a convexity in front of the sacrum and the **bladder** by a larger convex prominence behind the pubic bones. If the **ureter,** at its point of entrance into the pelvic cavity, be gently pulled upon, it will be seen to produce a ridge in the peritoneum extending from that point to the postero-lateral aspect of the bladder. In front of this ridge, between the undistended or partially distended bladder and the lateral pelvic wall, is seen a depression, the **paravesical fossa,** which is crossed obliquely from before backward and without inward by a slight ridge caused by the **vas deferens.** The sacro-genital fold, behind and internal to the ridge caused by the ureter and parallel with it, separates the **pararectal fossa,** situated beside the rectum, from the **middle** or **genital fossa.** The latter is therefore between the fold of the ureter and the sacro-genital fold.

The **pelvic peritoneum** should be followed from the termination of the sigmoid colon opposite the third piece of the sacrum to the upper part of the anterior surface of the rectum, where its two folds diverge to become parietal peritoneum. If the upper part of the rectum be drawn somewhat upward—the bladder having previously been injected with about six ounces of fluid—the peritoneum may be followed from the anterior surface of the rectum to the posterior surface of the bladder, as the **recto-vesical fold.** The lateral continuations of the posterior layer of this fold may be traced from the anterior surface of the rectum to the wall of the pelvis, becoming thus parietal peritoneum. The lateral extensions of the anterior layer of the fold may be traced upon the lateral surfaces of the bladder, upon which surfaces they descend to the level of a line leading from the urachus, at the summit of the bladder, to a point about one inch above the prostate (Fig. 333), from which lines they are reflected to the lateral walls of the pelvis as the lateral **false ligaments** of the bladder. The lateral portions of the horizontal part of the recto-vesical fold are designated the *sacro-genital folds*; they enclose portions of the seminal vesicles and of the vasa deferentia and some unstriped muscle, the *recto-vesicalis*. Tracing the anterior layer of the recto-vesical fold upward over the posterior surface of the bladder, it will be seen to leave that viscus at its summit, following the urachus to the anterior abdominal wall and thus constituting the **anterior false ligament** of the bladder (lig. umbilicale medium).

The Bladder.—The summit of the bladder is connected with the umbilicus by the impervious cord, the **urachus,** which is the remnant of a portion of the allantois (Fig. 296). It is also connected with the anterior abdominal wall by the impervious remnants of the fetal hypogastric arteries of which the superior vesical arteries of the adult constitute the persistent portions. Reference has been made to these structures in the dissection of the anterior abdominal wall (p. 615). The lower part or base of the bladder presents the urethral orifice and comes into relation with the base of the prostate. The *peritoneal relations* of the bladder were considered in the preceding paragraph; so far as the peritoneum is in relation with the bladder, it constitutes one of its coats, the outermost or **serous coat.** The space between the anterior surface of the bladder and the symphysis pubis, occupied by areolar tissue, is known as the **prevesical space** or **space of Retzius.**

From what has been said of the *peritoneal relations* of the bladder it is apparent that the anterior surface, the lower part of the lateral surface and the part of the posterior surface below the level of a line about an inch above the prostate or about two and one half inches from the anus, is devoid of peritoneal investment. The position of this line, however, varies with the degree of distention of the viscus, the line being at a higher level the more the bladder is distended. In the operation of opening the bladder through the anterior abdominal wall, *suprapubic cystotomy*—the bladder having been distended by a sterile fluid and so made to rise—the organ

may be reached without trespassing upon the peritoneal cavity. If the bladder is **ruptured** by traumatism, as in the case of a blow upon the abdomen or in fracture of the pelvic bones, the position of the rent will determine the consequences that ensue upon extravasation of its contents; thus, after extravasation through a non-peritoneal part of the wall the urine infiltrates the areolar tissue of the pelvis and sets up a *pelvic cellulitis*. If the rupture occurs through any part of the peritoneal surface, the peritoneal cavity is invaded by the urine, causing a rapidly developing *peritonitis*.

The peritoneal investment of the bladder may be now stripped off and the peritoneum may also be removed from the pelvic walls, with care to avoid injuring the ureters, the vasa deferentia, the obturator nerve and artery along the upper part of the lateral wall and the nerves of the hypogastric and pelvic plexuses more posteriorly.

The **fibrous tunic** of the bladder is thus brought to view. This layer of fibrous tissue, directly continuous with the visceral layer of the pelvic fascia, although well-developed below, thins out materially over the upper part of the bladder.

The Pelvic Fascia.—The pelvic fascia lines the pelvic cavity as the **parietal portion** of the fascia, being attached above along the posterior portions of the ilio-pectineal lines where it is continuous with the psoas and iliac fascia, and farther forward to the lateral pelvic walls below these lines. On the posterior wall of the pelvis, it covers the pyriformis and the sacral and pudendal plexuses of nerves. Passing downward over the pelvic surfaces of the obturator internus muscles (Fig. 335), it divides into two layers at the level of the line extending from the lower part of the symphysis pubis to the spine of the ischium, the so-called **white-line** of the pelvic fascia (Fig. 336). The more external of these layers continues downward over the inner surface of the obturator internus muscle as the **obturator fascia** (Fig. 332), helping to constitute the outer wall of the ischio-rectal fossa (p. 564) and being continuous across the anterior part of the pelvic outlet with the corresponding fascia of the opposite side, thus constituting the *deep layer of the triangular ligament*. The inner layer, sometimes described as simply the continuation of the pelvic fascia but known also as the **recto-vesical** or **visceral layer,** passes downward and inward upon the upper or pelvic surface of the levator ani muscle and when it reaches the prostate gland, the bladder and the rectum, passes upon the surfaces of these respective organs contributing their fibrous investment (fascia endopelvina).

In the posterior part of the pelvis, the visceral layer is pierced by the rectum and is reflected upon that tube as the *rectal fascia*. More anteriorly, it passes upon the posterior surface of the bladder and forms a strong sheath for the seminal vesicles (p. 572); to this portion of the visceral layer, some anatomists restrict the term *recto-vesical fascia*. Still farther forward, the visceral layer turns upward upon the base and sides of the bladder, as the **lateral true ligaments of the bladder**, which

are continued upward as the *vesical fascia* to contribute to the fibrous tunic of that organ. From the line of its reflection upon the bladder, the visceral layer also passes downward upon the prostate, enveloping the latter in a loose sheath (p. 571); this sheath becomes continuous at the apex of the prostate with the deep layer of the triangular ligament (a part of the parietal pelvic fascia) and is continued forward in the form of two bands, the **pubo=prostatic ligaments** or **anterior true ligaments of the bladder,** to be attached to the pubic bones just above the attachments of the levatores ani to these bones.

If the fibrous tunic of the bladder be dissected off, the **vesical plexus of veins** will be exposed; these vessels are largest at the base of the bladder (Fig. 334). Beneath them will be found the **muscularis** of the organ.

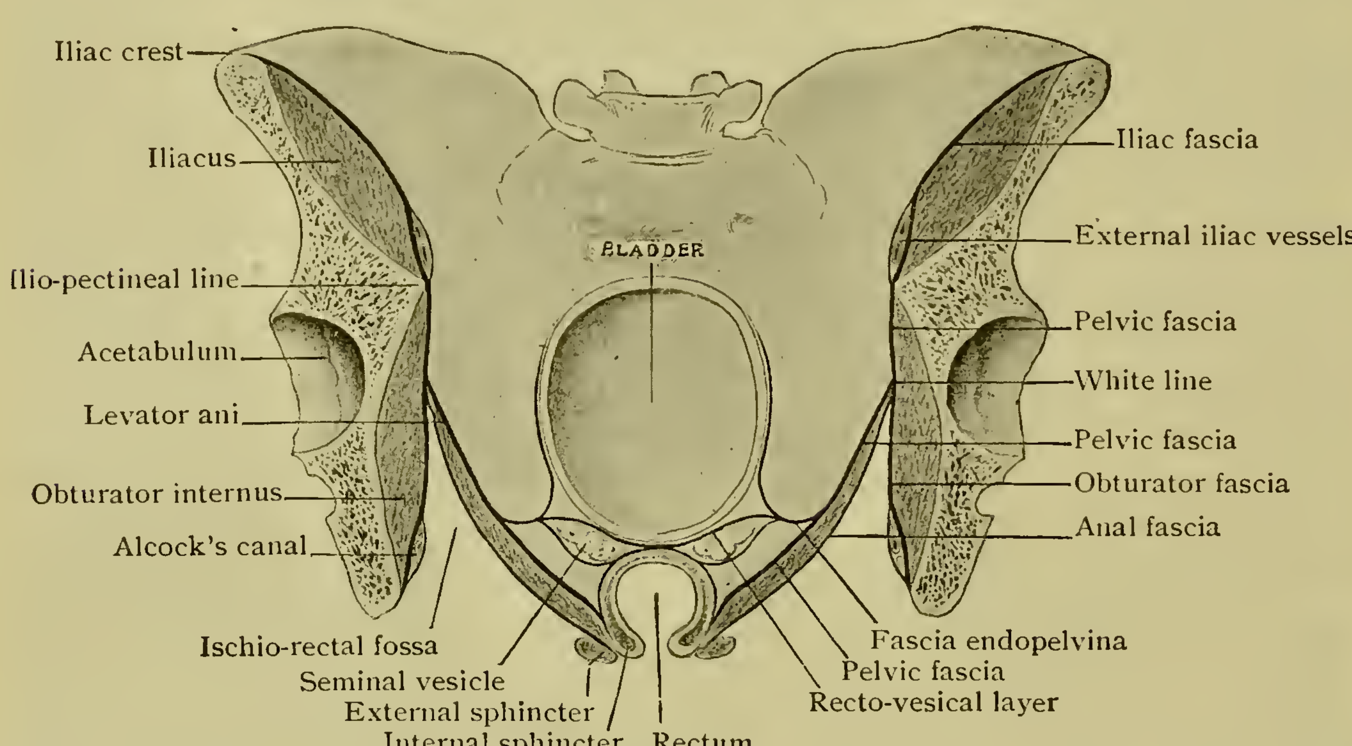

FIG. 332.—Diagrammatic frontal section through pelvis, showing relations of fascial layers to pelvic wall and floor.

The **pelvic stage of the ureter** should now be traced from the termination of the abdominal stage at the brim of the pelvis (p. 671). Tracing it downward in front of the internal iliac artery, along the lateral pelvic wall where it crosses the inner aspect of the obturator nerve and vessels, it will be followed to the wall of the bladder and seen to cross the vas deferens on its outer side and to enter the posterior wall of the bladder near or under cover of the upper anterior part of the seminal vesicle (Fig. 326). The **vesical stage** is that part of the ureter, three fourths of an inch in length, which lies within the bladder wall as it obliquely perforates the latter to reach the outer angle of the vesical trigone (p. 700).

That part of the posterior surface of the bladder which is in relation with the seminal vesicles and the vasa deferentia has been examined in connection with the dissection of the perineum (p. 571), as has also the

surface of the prostate (p. 571). These structures cannot be satisfactorily studied in working through the pelvic cavity, but the prostate may be palpated by passing the finger downward to the floor of the pelvis and then directing it forward toward the pubic arch.

The Rectum.—The rectum **begins** at the termination of the sigmoid colon opposite the third piece of the sacrum a little to the left of the mid-line. It includes a **first portion,** beginning as just indicated and extending to a point opposite the tip of the coccyx, the length of which is from three and one half to four and one half inches, and a **second portion** extending from opposite the tip of the coccyx to the anal aperture. The relation of the peritoneum to the rectum, although previously considered (p. 630), may be noted again as being a limited relation, the peritoneum covering merely the upper part of the anterior surface from which it is reflected to the posterior surface of the bladder. It is to be noted that the rectum is sometimes described as beginning at the left sacro-iliac synchondrosis, making it include, therefore, what is usually described as a portion of the sigmoid. (According to this nomenclature the upper part of the rectum receives a complete investment of peritoneum and is provided with a mesentery, the meso-rectum.)

The **blood-supply** of the rectum is through the superior hemorrhoidal branch of the inferior mesenteric artery, the middle hemorrhoidal branches of the posterior trunk of the internal iliac and the inferior hemorrhoidal branches of the internal pudic artery. The first of these and, to some extent, the second, may be dissected within the cavity of the pelvis by pulling the rectum forward and following the superior hemorrhoidal downward to the posterior aspect of the rectum, and noting its communications with the middle hemorrhoidal arteries. The **veins** corresponding to these arteries have been sufficiently referred to (p. 640).

In a preparation in which the organs have been hardened *in situ*, the right wall of the rectum presents an indentation (Fig. 319) which is so deep as to form a projecting fold on the interior of the bowel known as the *third sphincter* of Hyrtl or the *plica transversalis recti*. This is situated opposite the point of peritoneal reflection. Similar but less marked indentations on the left wall, one above and one below the transverse plica, give rise also to folds which project into the lumen of the bowel. These folds cannot be studied at the present stage of the dissection, but at a later stage, upon the removal of the rectum from the pelvic cavity and its distention with fluid or with tow or cotton and its subsequent drying, they may be demonstrated.

The **nerves** of the rectum are derived from the pelvic plexuses of the sympathetic, to which important contributions are made by the visceral branch of the fourth sacral nerve of each side.

The **second part** of the rectum or the **canal of the anus,** the origin and termination of which have been indicated above, is one inch in length

and comprises that portion of the bowel which is surrounded by the internal sphincter. The *internal sphincter* is merely an aggregation of the circular muscular fibres of the bowel and is therefore composed of involuntary or unstriated muscle. Owing to the tonic contraction of this muscle, the canal of the anus differs markedly from the lumen of the first part of the rectum in the fact that it is always closed, except when something is passing through it. The interior of the canal presents numerous longitudinal ridges, the *columns of the rectum*, produced by the foldings of the mucosa and submucosa.

This completes the dissection of the viscera of the male pelvis so far as they can be dissected *in situ* and the dissector may now proceed to the consideration of the pelvic walls.

THE WALLS OF THE PELVIS.

The **hypogastric plexus of the sympathetic,** continued over the *posterior wall* of the pelvic cavity from the lower part of the abdominal cavity over the lower part of the abdominal aorta and its bifurcation, is recognized as a plexiform arrangement of broad bands (Fig. 322). Traced downward, this plexus is seen to divide into the *right* and *left pelvic plexuses* which lie one on either side of the rectum.

The **pelvic plexuses** (plexus hypogastrici inferiores), resulting from the bifurcation of the hypogastric plexus, should be followed downward on either side of the rectum along the course of the internal iliac artery. The component fibres of this plexus, other than those continued from the aortic plexus, including the branches of the pudendal plexus (the *visceral branches* of the second and third or of the third and fourth sacral nerves) and the *visceral branches* of the upper sacral ganglia of the sympathetic, should be sought and traced to their respective sources.

The **branches** of the pelvic plexuses are the *middle hemorrhoidal plexus*, to the rectum, which communicates with the plexus of the superior hemorrhoidal artery; the *vesical plexus*, running in company with the vesical arteries to the base of the bladder and the seminal vesicles; and the *prostatic plexus* to the base of the bladder and the lateral aspect of the prostate. The continuation of the prostatic plexus through the triangular ligament is the **cavernous plexus,** the *branches* of which are the *short cavernous nerves* to the proximal part of the cavernous body of the penis, and the *long cavernous nerve* which runs along the dorsum of the penis, breaking up into branches that enter the corpus cavernosum. These plexuses and their branches are to be followed as far as may be possible at this stage of the work, their dissection being completed after the section of the pelvis.

To gain access to the remaining structures in the pelvic cavity, it is necessary or at least desirable to remove the lateral pelvic wall of

one side. Assuming that the left wall is the part to be removed, let the dissector first clean as much of the *left internal iliac artery and vein* (Fig. 326) as may be conveniently reached, stripping off the parietal peritoneum of the left pelvic wall if this has not been done. Pulling the artery away from the wall of the pelvis, the *superior gluteal* and the *sciatic* and *internal pudic branches* (Fig. 333) should be cut as they are about to perforate the parietal pelvic fascia to leave the pelvic cavity through the greater sacro-sciatic foramen, the *obturator* and *ilio-lumbar branches* (Fig. 333) being also severed near their points of origin. The *left external iliac artery and vein* should be cut at the origin of the former and the termination of the latter, the *vas deferens* being divided where it crosses these vessels, while the *left ureter*, the *bladder* and the remaining *branches of the internal iliac artery* should be crowded toward the mesial plane of the body. If the left psoas magnus has not been removed, it and the trunks of the lumbar plexus it contains must be cut opposite the sacro-iliac articulation (Fig. 326).

The *parietal pelvic fascia* (p. 687) should be cut along its attachment to and near the brim of the true pelvis on the left side and should be separated from the obturator internus, the pyriformis and the sacral nerve-trunks by blunt dissection, and drawn toward the mesial plane. The left pubic bone should now be sawn about a half inch to the left of the symphysis, and the left sacro-iliac joint divided with the cartilage-knife or saw. Tilting outward the part of the left innominate bone thus separated, a knife should be passed along the margin of the great sacro-sciatic foramen, severing the pyriformis and the nerve-trunks of the sacral plexus. Identifying the spine of the ischium with the tip of the finger, the attachment to it of the coccygeus muscle and of the small sacro-sciatic ligament must be severed. Now passing the knife along the inner margin of the tuberosity of the ischium and then forward along its ramus and the vertical ramus of the pubis, the greater sacro-sciatic ligament and the triangular ligament of the perineum will be cut. This will entirely free the sawn part of the left innominate bone.

The **sacral sympathetic ganglia** (Fig. 336), four or five in number and situated internal to the anterior sacral foramina, may be isolated one by one. The delicate (gray) *rami communicantes* which connect these ganglia with the corresponding sacral nerves may be easily overlooked, but are not especially difficult to find. The same remark applies to the branches which these ganglia send to the pelvic plexuses. The **coccygeal ganglion** or **ganglion impar** is, as its name implies, an unpaired structure and lies in front of the coccyx, being connected with the last sacral ganglion of each side by an interganglionic cord. The other structures in relation with the posterior pelvic wall, the sacral nerves, may be left for the present.

The *lateral wall* of the pelvis, which presents the obturator internus muscle covered by the pelvic fascia (p. 687), has in relation with it important vessels and nerves.

The **obturator nerve** (Fig. 334), recognized as a white band running horizontally about three-fourths of an inch below the margin of the true pelvis, should be picked up and traced forward to the upper part

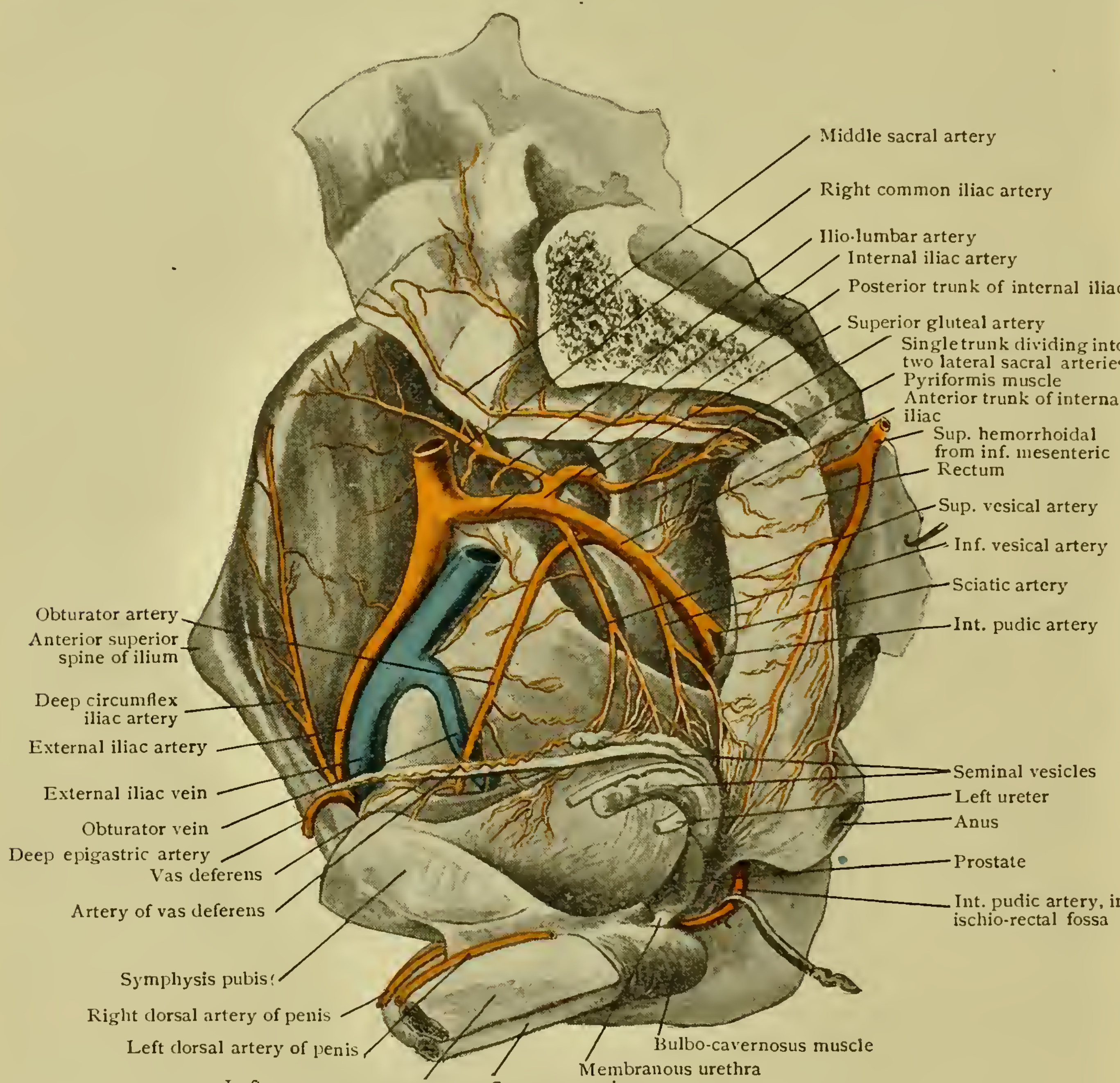

Fig. 333.—Dissection of pelvis of male, showing right internal iliac artery and its branches.

of the obturator foramen and backward and upward behind the common iliac vessels to its origin in the lumbar plexus (the second, third and fourth lumbar nerves). Its further course concerns the dissector of the lower limb (p. 218).

The **obturator artery** lies just below the obturator nerve, in close relation with it, and above the obturator vein. After tracing it backward to its *origin* in the anterior trunk of the internal iliac artery, it

should be traced forward to the upper part of the obturator foramen, its point of exit from the pelvic cavity, where it pierces the pelvic fascia. The **branches** within the pelvis are the *iliac*, to the iliac fossa, *muscular branches*, *vesical branches* to the bladder and a *pubic branch*. The last named should be followed upward over the posterior surface of the pubis to its anastomosis with the pubic branch of the deep epigastric artery. As noted elsewhere (p. 202), the obturator artery sometimes arises from the external iliac near Poupart's ligament, or in common with the deep epigastric artery, and skirts either the inner or outer margin of the femoral ring on its way to the obturator foramen (Fig. 297).

The Internal Iliac Artery.—This vessel **arises** as a terminal branch of the common iliac artery and passes downward along the lateral pelvic wall, dividing at the upper margin of the great sacro-sciatic foramen into an *anterior* and a *posterior trunk*. The **branches of the anterior trunk** (Fig. 333) are the *superior vesical*, which passes toward the upper part of the bladder and represents the persistent portion of the fetal hypogastric artery; the *middle vesical* (often a branch of the superior vesical), passing to the bladder; the *inferior vesical*, which goes to the base of the bladder, the prostate and the seminal vesicles; the *obturator;* the *prostatic* (*vaginal* in the female); the *vesiculo-deferential* (*uterine* in the female); the *middle hemorrhoidal* and the two *terminal branches*, the *internal pudic* and the *sciatic artery*.

There is much variation in the origin of these branches. The vesical, the prostatic and the vesiculo-deferential arteries may arise by a common trunk, the *hypogastric axis*, or the inferior vesical may arise from the middle hemorrhoidal or from the prostatic, or the prostatic may arise in common with the middle hemorrhoidal artery. These branches should be successively followed.

The **vesiculo-deferential artery** should be traced forward to the seminal vesicles (Fig. 333), the *deferential branch* having been previously dissected for the most part (p. 628).

The **terminal branches** leave the pelvic cavity through the greater sacro-sciatic foramen below the pyriformis. Their further course is considered at pages 171 and 565.

The **branches of the posterior trunk** are the *ilio-lumbar*, the *lateral sacral* and the *superior gluteal*.

The **ilio-lumbar artery,** often arising near the origin of the internal iliac before its bifurcation, passes into the upper part of the iliac fossa beneath the psoas muscle (Fig. 333). Its **branches** are the *iliac* to the iliacus and the abdominal wall, and the *lumbar branch*, which supplies the psoas and quadratus and sends a small *spinal branch* into the spinal canal between the last lumbar and first sacral vertebræ.

The **lateral sacral arteries** (Fig. 333) (the two arteries may arise in common) pass toward the mid-line, distributing branches to the front

of the sacrum and sending spinal branches into the anterior sacral foramina to aid in the supply of the spinal cord and meninges, branches of which escape through the posterior sacral foramina to ramify upon the dorsal surface of the sacrum.

The **superior gluteal artery** leaves the pelvic cavity through the great sacro-sciatic foramen above the pyriformis; its further course is followed in the dissection of the lower limb (p. 169).

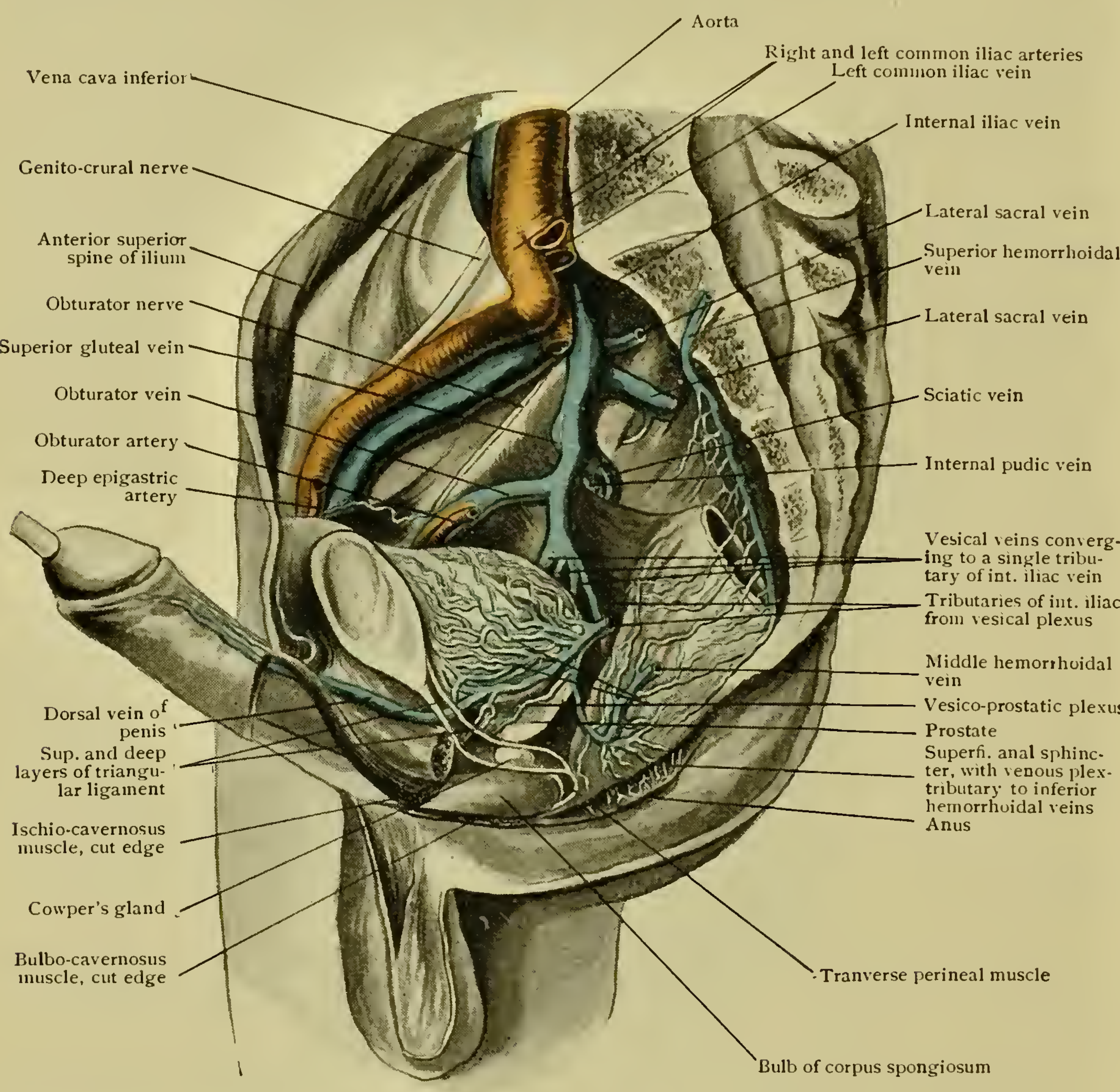

Fig. 334.—Veins of pelvis, viewed from left side.

The **internal iliac vein** is a large trunk which *originates* by the confluence of the veins corresponding to the branches of the internal iliac artery. It *terminates* by joining the external iliac vein to form the common iliac vein. It lies upon the posterior aspect of the internal iliac artery (Fig. 326).

The **relations** of the internal iliac artery have been demonstrated in dissecting it. On its *outer side* are the psoas muscle and the external

iliac vein; *behind* it are the internal iliac vein, the lumbo-sacral cord and the pyriformis; *in front*, the ureter and, in the case of the left artery, the rectum.

What was said with reference to ligation of the common iliac artery (p. 683) applies with equal force to this vessel.

The Coccygeal Body (glomus coccygeum).—The coccygeal body or gland, Luschka's gland, a body the size of a small pea, may be found in front of the tip of the coccyx attached to the front of the middle sacral artery, embedded in loose cellulo-fatty tissue.

The **parietal portion of the pelvic fascia** (p. 687) may now be examined, the **white line** being noted as a band stretching from the spine of

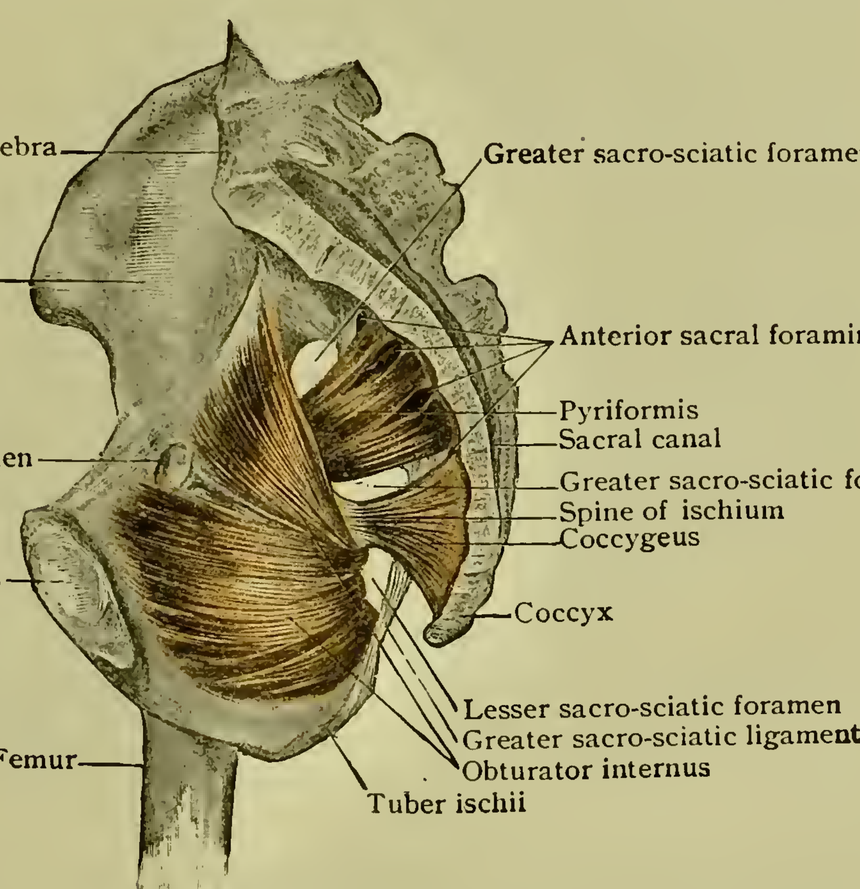

FIG. 335.—Dissection of right postero-lateral wall of pelvis from within, showing pyriformis and obturator internus muscles.

the ischium to the lower part of the body of the pubis (Fig. 336). The fascia should be cut along the lower border of the white line and carefully dissected from the pelvic surface of the levator ani muscle and traced toward the prostate, the bladder and the rectum, its reflections upon the surfaces of these organs being noted (pp. 687 and 688). Detaching the upper border of the parietal division of the fascia from the pelvic wall and dissecting it up as was done on the left side, the *obturator internus*, the *pyriformis*, the *coccygeus* and the *sacral nerves* are exposed.

OBTURATOR INTERNUS (Fig. 335).—**Origin**, the inner surface of the lateral wall of the pelvis including the body of the ischium, the body

and horizontal ramus of the pubis and a small part of the ilium; **insertion,** the upper border of the great trochanter of the femur in company with the gemelli; **nerve-supply,** the obturator nerve; **action,** internal rotation of the femur.

By displacing somewhat the vessels and nerves in relation with the inner surface of this muscle, the pelvic fascia which covers it having been previously removed, the direction of the muscular fibres may be appreciated. The latter, passing downward, converge toward the lesser sacro-sciatic foramen through which the tendon makes its exit from the pelvis and passes in a direction at right angles to the body of the muscle to reach its destination (Fig. 86).

The Sacral Plexus.—The sacral plexus will be found, upon removal of the parietal layer of the pelvic fascia, on the pelvic surface of the pyriformis muscle (Fig. 336). Carefully removing the loose cellular tissue and denuding the trunks of the plexus, with care to detect and preserve the small branches, it will be seen that the upper broad band, the **lumbo-sacral cord,** is double and that it results from the union of the anterior and posterior branches of the lower, smaller part of the *fourth lumbar nerve* (nervus furcalis) with the anterior and posterior branches of the *fifth lumbar.* The ilio-lumbar vessels pass above it. The second broad band below this is the **first sacral nerve** which should be traced to the first anterior sacral foramen. The superior gluteal vessels, after piercing the pelvic fascia, pass between this nerve and the lumbo-sacral cord. Farther down, the **second** and **third sacral nerves** should be picked up and traced to the corresponding sacral foramina. Traced distally, each of these trunks will be seen to divide into two. The anterior division of the lumbo-sacral cord unites with the anterior divisions of the first and second and the upper division of the third sacral nerves to form the **internal popliteal nerve** (nervus tibialis), while the posterior divisions of the cord and of the first and second sacrals combine to form the **external popliteal** or **peroneal nerve** (nervus fibularis). These may leave the pelvis (through the greater sacro-sciatic foramen) as entirely separate trunks or may unite loosely to form the **great sciatic nerve,** but still preserving their individuality.

The **branches** of the sacral plexus are, besides the two terminal branches, the *tibial* and *fibular nerves* (pp. 178 and 179), the *anterior* (muscular and articular) and the *posterior* (muscular and articular). The **articular branches** run in company with the muscular branches from which they diverge outside the pelvic cavity (pp. 174 and 189). All branches that leave the pelvis do so by traversing the greater sacro-sciatic foramen.

The **anterior muscular branches** include:—The *nerve to the quadratus femoris,* which arises from the front surface of the plexus (Fig. 336) sometimes in common with the nerve to the obturator internus; for

its course, see page 189. The *nerve to the obturator internus* and the *gemellus superior* (Fig. 336), after leaving the pelvis and supplying the gemellus, crosses the spine of the ischium (Fig. 85) and reaches the ischio-rectal fossa through the lesser sacro-sciatic foramen to reach the former muscle. The *nerve to the hamstring muscles* and the adductor magnus is associated with the great sciatic or with the internal popliteal nerve as far as the upper part of the thigh (p. 184).

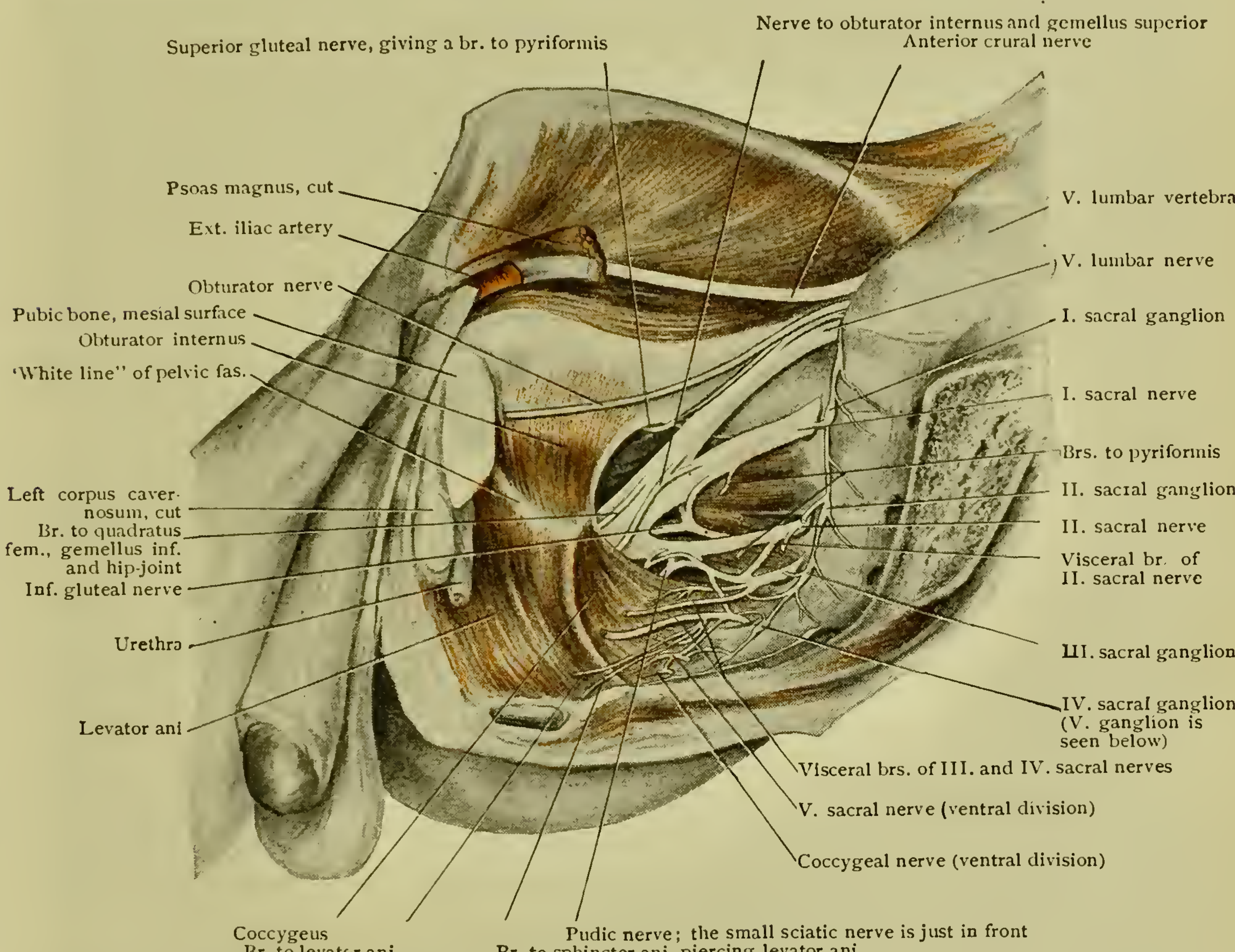

FIG. 336.—Dissection of right half of pelvis, showing sacral and pudendal plexuses; section is not mesial, but to left of mid-line.

The **posterior muscular branches** include:—The *nerve to the pyriformis* (Fig. 336), which arises from the first and second sacral nerves or from the second only. The *superior gluteal nerve* (Fig. 336), arising by three roots from the lumbo-sacral cord and the first sacral nerve, is considered at page 170. The *inferior gluteal nerve* (Fig. 336), sometimes associated with the small sciatic, is considered at page 172.

The Pudendal Plexus.—This small plexus will be found on the posterior wall of the pelvis, resting upon the coccygeus muscle, upon removing the rectum and the pelvic fascia (Fig. 336). The third sacral nerve having been identified, the **fourth** and **fifth sacral nerves**—*i.e.*,

the primary divisions in each case—should be found at their points of emergence through the anterior sacral foramina, the fifth nerve being seen to pierce the coccygeus muscle to reach its ventral surface. The **coccygeal nerve** will be seen to pierce the muscle a little lower, having come forward between the first and second segments of the coccyx. If the communications between these nerves and the branches that join them from the first and second sacral nerves be found, the pudendal plexus will be seen to be composed of the fourth and fifth sacral nerves aided by contributions from the first three sacral nerves and from the coccygeal nerve as well as by the gray rami from the sacral sympathetic ganglia.

The **branches** of the pudendal plexus are the *visceral*, the *muscular*, the *perforating cutaneous*, the *small sciatic*, the *pudic* and the *sacro-coccygeal*. The **visceral branches** have been mentioned (p. 690) as joining the pelvic plexuses.

The **muscular branches** include *one to the external sphincter* and *coccygeus* which may be traced to the surface of the latter muscle, which it pierces prior to its perforating the greater sacro-sciatic ligament on its way to the ischio-rectal region (p. 563). The *nerve to the levator ani* may be followed to the pelvic surface of that muscle (Fig. 336).

The **perforating cutaneous nerve**—not constant—arises from the second and third sacral nerves and pierces the greater sacro-sciatic ligament to be distributed to the adjacent integument (p. 169).

The **small sciatic nerve** (n. cutaneus femoris posterior) will be found arising from the second and third and also sometimes from the first sacral nerves, on their dorsal aspects (Fig. 336) and should be followed to the greater sacro-sciatic foramen; its further course is noted at pages 176 and 183.

The **pudic nerve** (n. pudendus) should be traced from its origin in the second, third, and fourth sacral nerves (Fig. 336) to its place of exit through the greater sacro-sciatic foramen; its subsequent course has been followed (pp. 175 and 564).

The **sacro=coccygeal nerves** (nn. anococcygei) arise from the fourth and fifth sacral and the coccygeal nerves, the filament from the fourth joining the fifth nerve, the resulting trunk then uniting with the coccygeal nerve to form the so-called *coccygeal plexus* (Fig. 281). These nerves supply the skin of the coccygeal region after perforating the greater sacro-sciatic ligament.

Coccygeus (Fig. 335).—**Origin,** by its apex from the spine of the ischium; **insertion,** by its base into the lateral margin of the coccyx and of the lower part of the sacrum; **nerve=supply,** the sacral plexus; **action,** to draw forward the coccyx.

The pelvic surface of this muscle which helps the levator ani and the triangular ligament to form the floor of the pelvic cavity, is to be exposed by somewhat displacing the trunks of the sacral plexus which lie upon it.

Pyriformis (Fig. 335).—**Origin,** by three processes from the front of the sacrum between the first and second, the second and third, and the third and fourth sacral foramina, and by a small fasciculus from the outer margin of the great sacro-sciatic foramen; **insertion,** the upper margin of the great trochanter of the femur (Fig. 86); **nerve-supply,** the sacral plexus; **action,** external rotation of the femur.

The fleshy mass which this muscle forms is partially concealed by the trunks of the sacral plexus.

The Walls of the Bladder.—The walls of the bladder have been seen to include an outer **serous coat** and a second **fibrous coat.**

The **muscular tunic** should now be demonstrated by dissecting off at least a portion of the fibrous coat. If the walls have become flabby, more fluid should be injected to make the viscus sufficiently tense. The *external longitudinal* muscular fibres, most abundant on the lower and upper surfaces, will be first encountered. Some of them pass forward as the muscular parts of the *pubo-prostatic ligaments* (p. 688), to be attached to the posterior surfaces of the pubic bones, and are continued backward to become attached to the prostate.

The *circular fibres* may be recognized as coarse bundles and as being aggregated at the urethal orifice to form a circular muscle or sphincter, continuous with the muscular structure of the prostate.

The *internal longitudinal fibres*, forming an incomplete layer, are found chiefly on the inferior part of the wall.

The **mucosa,** separated from the muscular tunic by the submucosa, is to be inspected after the removal and opening of the bladder.

The bladder, the prostate and the penis should now be removed by detaching the bladder and prostate from the pelvic floor, severing the connections of the pubo-prostatic ligaments with the pubic bones, and detaching the crura penis from the ischiatic and pubic rami, taking the precaution to retain the sound in the urethra. The organs may now be placed on a board covered with several layers of damp gauze and fixed in position with push-pins, the dorsal surface of the penis looking upward. A median incision should now be made through the bladder-wall from the urachus along the anterior and inferior surfaces to the prostate. This cut should be extended through the upper surface of the prostate and along the entire length of the dorsal surface of the corpus spongiosum to the meatus urinarius, the corpora cavernosa being pulled aside. These incisions expose the interior of the bladder and that of the whole length of the urethra.

The **inner surface of the bladder-wall** as now seen presents a certain degree of rugosity because of the redundancy of the mucosa in the undistended condition of the organ and the looseness of the submucosa. There is a notable exception, however, to this arrangement, in a triangular area, the *trigonum vesicae*, at the lower part of the organ,

the mucosa here being smooth because intimately adherent to the subjacent muscular tissue (Fig. 337). The **bas-fond** of the bladder, *retro-trigonal fossa*, is the depressed portion in the infero-posterior wall just behind and above the trigone, since this part of the wall, not being supported by the prostate, bags somewhat. To better expose the trigone, the previous incision may be extended posteriorly and the walls of the bladder may be spread out upon the board and pinned down.

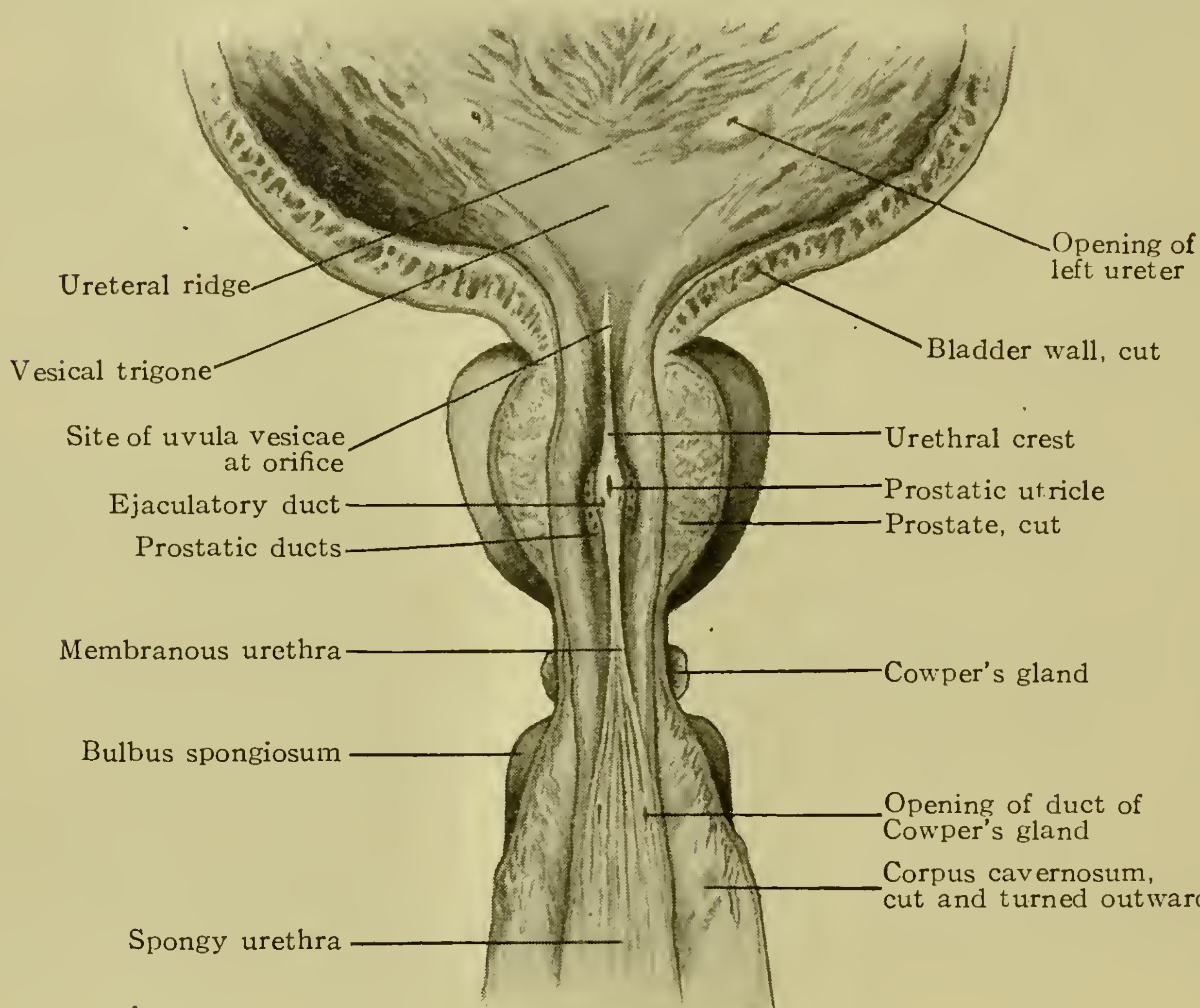

FIG. 337.—Part of bladder and male urethra, exposed by opening and turning aside anterior wall; showing posterior surface of prostatic, membranous, and beginning of spongy portions of urethra.

The **vesical trigone** will now be seen to be an almost equilateral triangle, the apex of which corresponds with the urethral orifice of the bladder, while the base, directed upward and backward, is represented by a slight fold or ridge, the *plica ureterica* or *torus uretericus*, which passes between the orifices of the ureters. The *orifices of the ureters*, therefore, are respectively at the lateral angles of the trigone and are about an inch apart. These should now be examined and found to present in each case a small fold or sort of valve; a small probe or a bristle should be passed into each ureteral orifice to demonstrate the oblique manner in which the ducts pierce the bladder-wall, an arrangement which subjects them to pressure as the bladder becomes distended

and so prevents back-flow of urine into the ducts. The *vesical crest* (uvula vesicae) is a small median longitudinal projection, a thickening of the mucosa enclosing muscular tissue, seen at the apex of the trigone; its continuity with the *urethral crest* of the prostatic urethra should be noted.

The peculiar arrangement of the circular muscular fibres of the bladder as noted above permits the development of the condition known as *sacculated bladder*, the mucous and submucous layers pouching between the muscular bundles in cases of prostatic or other form of obstruction, especially if associated with *atony* of the bladder-walls.

The vesical crest may be enlarged to such an extent in the aged as to obstruct the flow of urine. The sensitiveness of the trigonal area is exemplified by the pain experienced when a vesical calculus is jolted about in this region and by the intense desire to urinate aroused by bringing the tip of a catheter or sound in contact with it. The *reference of pain*, in case of *vesical calculus*, to the end of the penis, as well as to the anus, and even to the foot, is explicable upon recalling the nerve-supply of the bladder from the pelvic plexuses and the relations of these to the sacral nerves (p. 690).

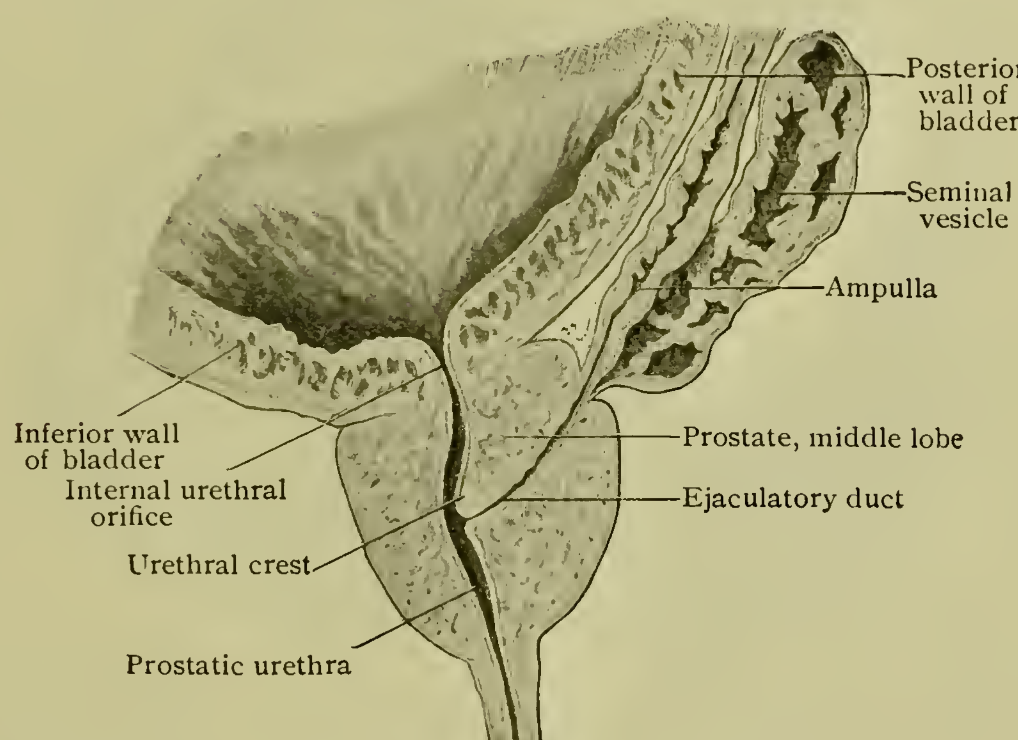

FIG. 338.—Portion of sagittal section, showing prostate and related structures.

THE MALE URETHRA.—The urethra, as now exposed, is seen to be surrounded at its beginning by the prostate gland and to traverse nearly the entire length of the corpus spongiosum after leaving the prostate and piercing the two layers of the triangular ligament. Its average total length is seven and a half inches (Fig. 334).

The Prostatic Urethra and the Prostate.—The prostatic urethra, homologous with the entire female urethra, is from three fourths to one and one fourth inches long and is the widest and most dilatable part of the urethra, never being the seat of stricture. The **urethral crest** or *verumontanum* or *caput gallinaginis*, continuous with the vesical uvula, projects from the floor or posterior wall, giving the *lumen* a crescentic shape in cross section. In the lateral portions, *i.e.*, the horns

of the crescent, are the orifices of the *prostatic ducts*, which the dissector should demonstrate by the introduction of bristles. The most prominent part of the urethral crest is the **colliculus seminalis**, presenting a narrow opening (Fig. 337), the orifice of the **sinus pocularis** (utriculus prostaticus), which may be demonstrated by the passage of a probe as a tubular pouch, one fourth to one half inch long running upward and backward. Its synonym, *uterus masculinus*, refers to its homology with the uterus, both being derived from the fused lower ends of Müller's ducts. On each lateral margin of its orifice is the opening of the corresponding *ejaculatory duct*, into which bristles or very fine probes

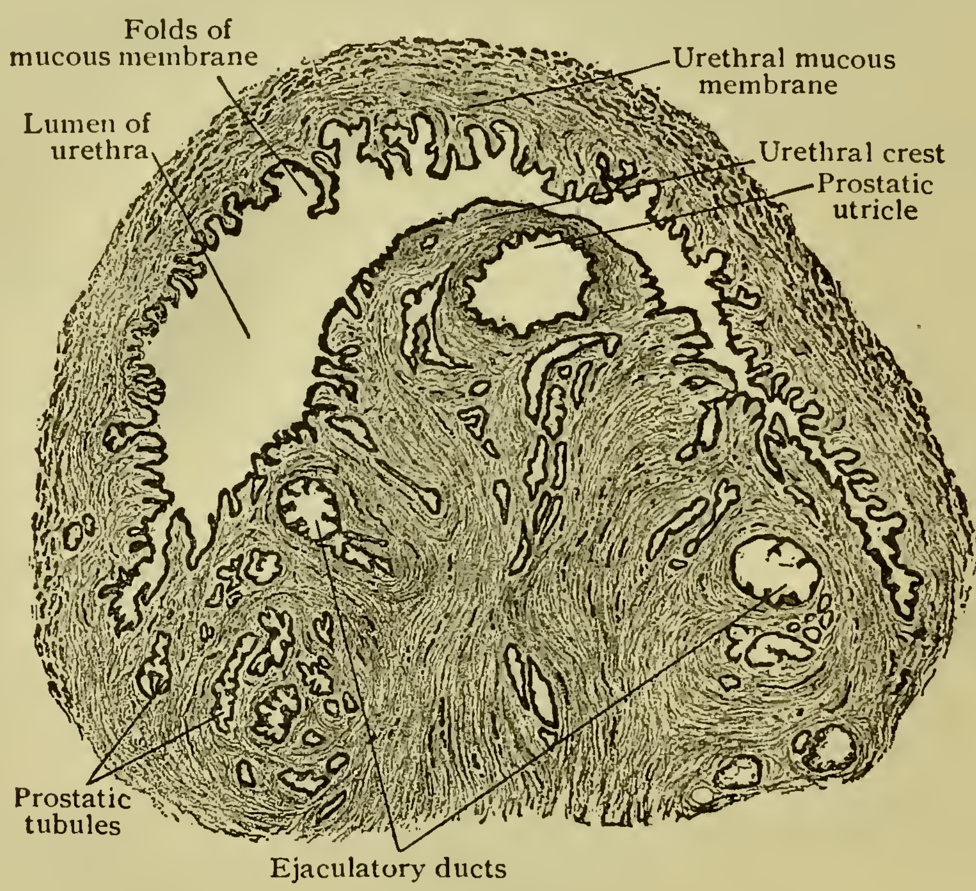

Fig. 339.—Section across prostatic urethra above entrance of ejaculatory ducts. showing crescentic form of urethral lumen produced by encroachment of urethral crest. × 10.

should be passed to define their course through the prostate. If this is successful, the limits of the **middle lobe** of the gland are indicated, this being that part of the organ behind the urethra and in front of the ducts, the base of which is in relation with the vesical trigone. The *unstriped muscular tissue of the prostate*, comprising about one fourth its bulk—one fourth being *connective tissue* and one half *glandular substance*—forms a ring around the prostatic urethra; its relation to the bladder-musculature has been noted (p. 699).

The prostatic urethra may be encroached upon even to the extent of occlusion by *enlargement of the prostate*, especially of the middle lobe (chronic prostatitis, prostatic hypertrophy). Such enlargement so increases the length of this part of the canal that a longer catheter

with a special curve is required for such patients. Moreover, such an elongated prostatic urethra may contain several fluidounces of urine in case of *retention from prostatic obstruction*, the involuntary sphincter at the orifice of the bladder having yielded as distention increased. If, upon catheterization in such case, the increased length of the canal is not taken into account, the evacuation of this urine which has accumulated in the urethra may give rise to the erroneous conclusion that the bladder has been emptied.

The Membranous Urethra.—The membranous urethra was seen in the dissection of the perineum (p. 569); it is that part of the canal contained within the deep perineal interspace and has a length of one third to one half inch. It is the narrowest and least dilatable part of the canal, and has a stellate *lumen* on cross section. Its relation to the compressor urethræ muscle has been seen (p. 569).

The Spongy Urethra.—The spongy portion of the urethra, contained within the corpus spongiosum and therefore often designated the *erectile portion*, begins in the bulb (p. 620) and ends at the meatus urinarius. In its bulbous portion, note the dilatation, the *fossa bulbi*, and the orifices of *Cowper's ducts* on its floor (p. 568). In the *penile portion*, note a similar but larger dilatation, the *fossa navicularis*, found within the glans.

Examination of the floor of the urethra with a hand-glass will reveal the apertures of the ducts of the *glands of Littré*. The *lacuna magna* should be noted as a small diverticulum on the roof of the navicular fossa. The *lumen* of the spongy urethra is a transverse slit, except in the fossa navicularis and at the meatus, where it becomes a vertical cleft.

In the introduction of a catheter or sound into the urethra it is well to bear in mind the situations of the orifices of the ducts opening into it ; thus, the beak of the instrument should hug the floor of the navicular fossa, but after passing this region, the roof of the canal.

When gonorrhœal urethritis is of intense degree, the periurethral tissue is implicated to such extent that the adjacent blood-spaces of the spongy body become filled with inflammatory exudate which prevents their being distended with blood during erection ; the spaces of the cavernous bodies being expanded to the normal degree, these bodies elongate, while the spongy body fails to do so, the result being a curved condition of the penis, *chordee*, which is extremely painful because of the mutual traction upon each other of the cavernous bodies and the inflamed spongy body.

Contraction of the organized periurethral inflammatory material produces narrowing or *stricture of the urethra*, which occurs most frequently in the membranous and bulbous portions and also within two inches of the meatus. Urethral strictures vary from a slight coarctation to such degree of occlusion of the canal as will not permit the entrance of an instrument, the latter type being distinguished as *impermeable*. *Permeable strictures* not amenable to treatment by gradual dilatation because of either toughness or resiliency are subjected to internal urethrotomy, while external urethrotomy is resorted to for impermeable and certain permeable strictures.

THE JOINTS OF THE PELVIS.

The pelvis—regarding the sacrum as a part of the pelvis—is connected with the lumbar spine by the lumbo-sacral articulation. The **ilio-lumbar ligament** should be exposed by removing the quadratus lumborum muscle and demonstrated to pass from the apex and front of the last lumbar transverse process to the crest of the ilium (Fig. 77).

The **sacro-lumbar** ligament will be seen going from the front of the same transverse process to the lateral part of the front of the base of the sacrum.

The Sacro-Iliac Articulation.—The surfaces involved in this **amphiarthrodial joint** are the auricular surface of the ilium (Fig. 78) and the auricular surface on the lateral aspect of the sacrum. The **ligaments** are the *anterior* and *posterior sacro-iliac*. The **anterior sacro-iliac ligament** connects the front of the lateral part of the sacrum with the adjacent part of the ilium. The **posterior sacro-iliac ligament** (Fig. 77), including *oblique* and *horizontal bands*, connects the upper three transverse tubercles on the dorsal surface of the sacrum with the posterior inferior spine of the ilium and the rough area of the ilium behind the auricular surface (Fig. 78). The left joint should be opened.

The Symphysis Pubis (Fig. 331).—Examination of this *amphiarthrosis* will show the inner articular surfaces of the pubic bones to be connected by bands distinguished as *anterior*, *posterior*, *superior* and *inferior pubic ligaments*. The **anterior ligament** consists of interlacing and decussating bands. The **inferior** or **subpubic ligament** is thick and triangular. Separating the remaining fragment of the left pubic bone (p. 691) from the right, the **interpubic disc** of fibro-cartilage will be found.

The **sacrum** and **ischium** are connected though not articulated by the *greater* and *lesser sacro-sciatic ligaments*. To study these, the pelvis should be separated from the trunk by disarticulating the fifth from the fourth lumbar vertebra.

The **great** or **posterior sacro-sciatic ligament** (Fig. 77), attached by its broad upper extremity to the posterior inferior iliac spine, the fourth and fifth transverse tubercles of the sacrum and the margin of the sacrum and of the coccyx, and below to the tuberosity of the ischium, should be carefully examined.

The **lesser** or **anterior sacro-sciatic ligament,** best seen from within the pelvis, should be cleared and its attachments by its apex to the spine of the ischium and by its base to the margin of the sacrum and of the coccyx should be noted (Fig. 77).

The relations of these ligaments to the sacro-sciatic foramina (p. 163), the structures transmitted by these foramina (p. 167) and the vessels and nerves that pierce the greater ligament (pp. 171 and 169) have been seen.

THE FEMALE PELVIS.

The noteworthy features of the bony pelvis are indicated at page 684. The **boundaries** of the female pelvis are the same as those of the male pelvis, but it represents some peculiarities as to form; *i.e.*, it is less massive, has greater width and less depth, the iliac fossæ are shallower, the anterior superior spines of the ilia are farther apart and the obturator foramina are smaller and more triangular. The superior strait is larger and more nearly circular, the sacro-vertebral angle being less projecting.

The **dimensions** of the **superior aperture** of the female pelvis are 4¾ inches for the *antero-posterior* or *conjugate diameter*, 5¼ inches

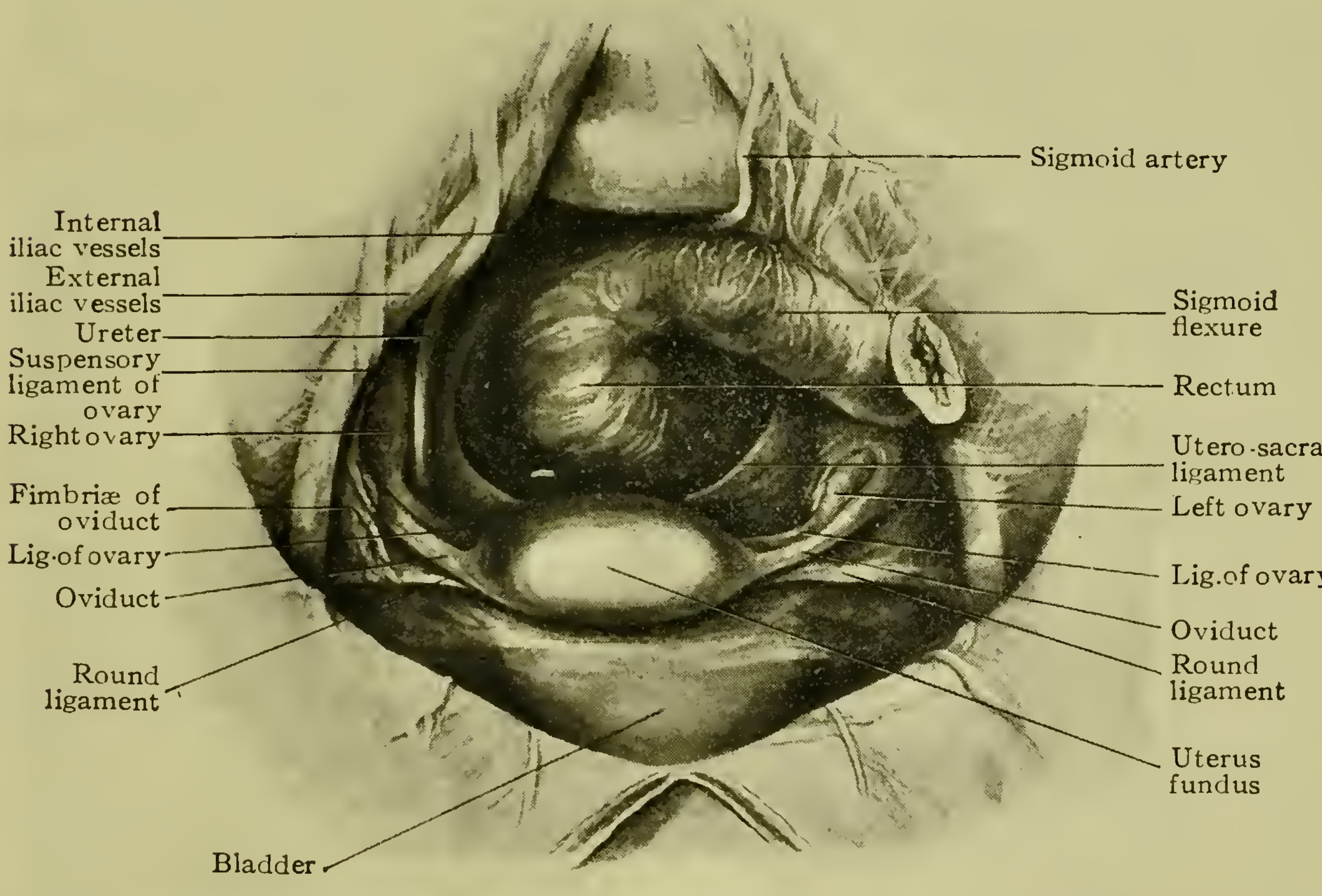

FIG. 340.—Pelvic organs of young woman viewed from above and in front; hardened *in situ* and undisturbed. Fimbriated extremity of right oviduct lay in position shown and not in relation with ovary.

for the *transverse diameter*, and 5 inches for the *oblique diameter* (from the sacro-iliac junction to the pectineal eminence), as compared with 4 inches, 4½ inches and 4¼ inches in the male pelvis respectively. The **outlet** or **inferior aperture** is larger and the coccyx more movable than in the male pelvis. The **dimensions** of the outlet are 5 inches for the *antero-posterior diameter*, and 4¾ inches for the *transverse diameter* (as measured from the posterior parts of the ischial tuberosities) as compared with 3¾ and 3½ inches respectively for the male pelvis.

The *contents* of the female pelvis are the rectum, a part of the sigmoid colon, the uterus, the ovaries, the vagina and the bladder.

The **pelvic peritoneum** should be followed from the termination of the sigmoid colon opposite the third piece of the sacrum to the upper part of the anterior surface of the rectum. From the rectum the peritoneum is reflected to the posterior surface of the uterus at its extreme lower limit, forming a pouch open upward, the **pouch** or **cul-de-sac of Douglas.** The peritoneum now continues upward over the posterior surface of the uterus to its upper limit, the right and left parts of this same fold, on the right and left sides of the uterus, passing upward almost to the level of its upper extremity to constitute the *posterior layer* of the **broad ligament of the uterus,** which, passing to the lateral wall of the pelvis, is continuous there in each case with the parietal peritoneum of the posterior part of the lateral wall. Following the peritoneum downward upon the anterior surface of the uterus, it will be noted to leave that organ before it reaches its lower extremity to pass to the posterior surface of the bladder, the more laterally placed portions of this same fold constituting the *anterior layer* of the broad ligament and reaching the lateral pelvic wall on either side to become the parietal peritoneum of the anterior portion of that wall. Following the peritoneum upward over the posterior surface of the bladder and over the summit of this organ, it may be traced to the anterior abdominal wall as in the case of the male, covering the urachus in the mid-line and the remnants of the obliterated hypogastric arteries on either side of the mid-line (Fig. 303) (p. 615).

The Uterus.—Drawing the upper end of the rectum backward and the upper part of the uterus forward, the posterior surface of this organ and the posterior surface of the broad ligament may be examined. The *ovary* appears as a projection from the posterior surface of the broad ligament in close relation with the lateral pelvic wall on each side. If the ovary be grasped between the fingers, it becomes evident that it is, as it were, pulled out from the broad ligament and is covered by a prolongation of that membrane to constitute a mesentery, the *mesovarium.* The position of the uterus normally is what is known as the position of anteflexion, that is, its long axis inclines forward from the long axis of the body so that the upper part of the organ lies almost in the horizontal plane (in the erect position of the body), the degree of this forward inclination necessarily varying according to varying degrees of distention of the bladder. The shape of the organ resembles that of a pear flattened antero-posteriorly, the larger end or **fundus** being directed upward and forward and the smaller end or termination of the neck being directed downward. In the nulliparous organ, the **neck** comprises about half the total length of the uterus (3½ inches), the point of continuity of the neck with the **body** of the organ being known as the **isthmus.**

The *peritoneal relations*, as indicated above, consist in a complete peritoneal covering for the posterior surface, while the anterior surface is invested with peritoneum for approximately the upper three fourths of its extent (Fig. 303).

The **oviducts** or **Fallopian tubes** (tubae uterinae) pass from the upper lateral parts of the uterus outward toward the lateral pelvic walls between the layers of the broad ligament and along the upper border of the latter (Fig. 341). Each duct consists of an inner narrower portion, the **isthmus,** by which it is connected with the uterus; of a larger, more external portion, the **ampulla;** and of a still larger and more external segment, the **infundibulum,** which opens by an expanded orifice, the **ostium abdominale,** the margins of which constitute the fimbriated extremity of the tube or the **fimbriæ.** One of these fringes or fimbriæ, the *fimbria ovarica*, usually becomes attached to the ovary near its upper pole, or lower, along the median surface (Fig. 342).

The tube, traced from the uterus along the upper margin of the broad ligament toward the pelvic wall, will be seen to dip downward to the lower pole of the ovary and then to curve sharply upward to run along the anterior border of the median surface of the ovary to its upper extremity, when it bends downward along its posterior border. The portion of the broad ligament which encloses the oviduct is called the *mesosalpinx.*

The Fallopian tube constitutes an avenue of communication between the cavity of the uterus and the peritoneal cavity, opening into the latter in close proximity to the ovary. When an ovum is extruded from the ovary by the rupture of the mature Graafian follicle, the ovum escapes into the peritoneal cavity and, since the walls of this cavity are everywhere in contact, the direction of least resistance is along the fimbria ovarica to the abdominal ostium of the oviduct.

The lumen of the oviduct being very small, it is easily occluded by the inflammatory process frequently seen here as a result of infection, such occlusion of the duct leading to retention of the products of inflammation, constituting the condition known as *pus-tubes* or *pyosalpinx.*

The Ovary.—This gland, about the shape and size of an ordinary almond, is enclosed by the posterior layer of the broad ligament so drawn out as to constitute a mesentery or mesovarium in such manner that the ovary appears to lie behind the broad ligament. The long axis of the gland is vertical; its *mesial surface* looks toward the uterus and the *lateral* or *outer surface* is in relation with the lateral pelvic wall just below the pelvic brim, in contact with a depression between the internal and external iliac vessels, the *ovarian fossa* (Fig. 341). The *anterior* or *attached border* points toward the broad ligament, and includes the *hilum*, the area through which the ovarian vessels and nerves enter after having reached the ovary between the two layers of the meso-

varium. The *posterior border* is free. The fimbria ovarica, one of the fringes of the fimbriated extremity of the oviduct, is attached to some part of the inner surface as noted above. The upper or *tubal pole* is attached to the suspensory or infundibulo-pelvic ligament; the *lower* or *uterine pole* gives attachment to the utero-ovarian ligament (Fig. 341).

The **blood-supply** of the ovary is the ovarian artery from the abdominal aorta and ovarian branches of the uterine artery. Passing through the infundibulo-pelvic ligament to gain a position between the two layers of the broad ligament, the **ovarian artery** sends branches to the oviduct, branches to communicate with the uterine artery and ovarian

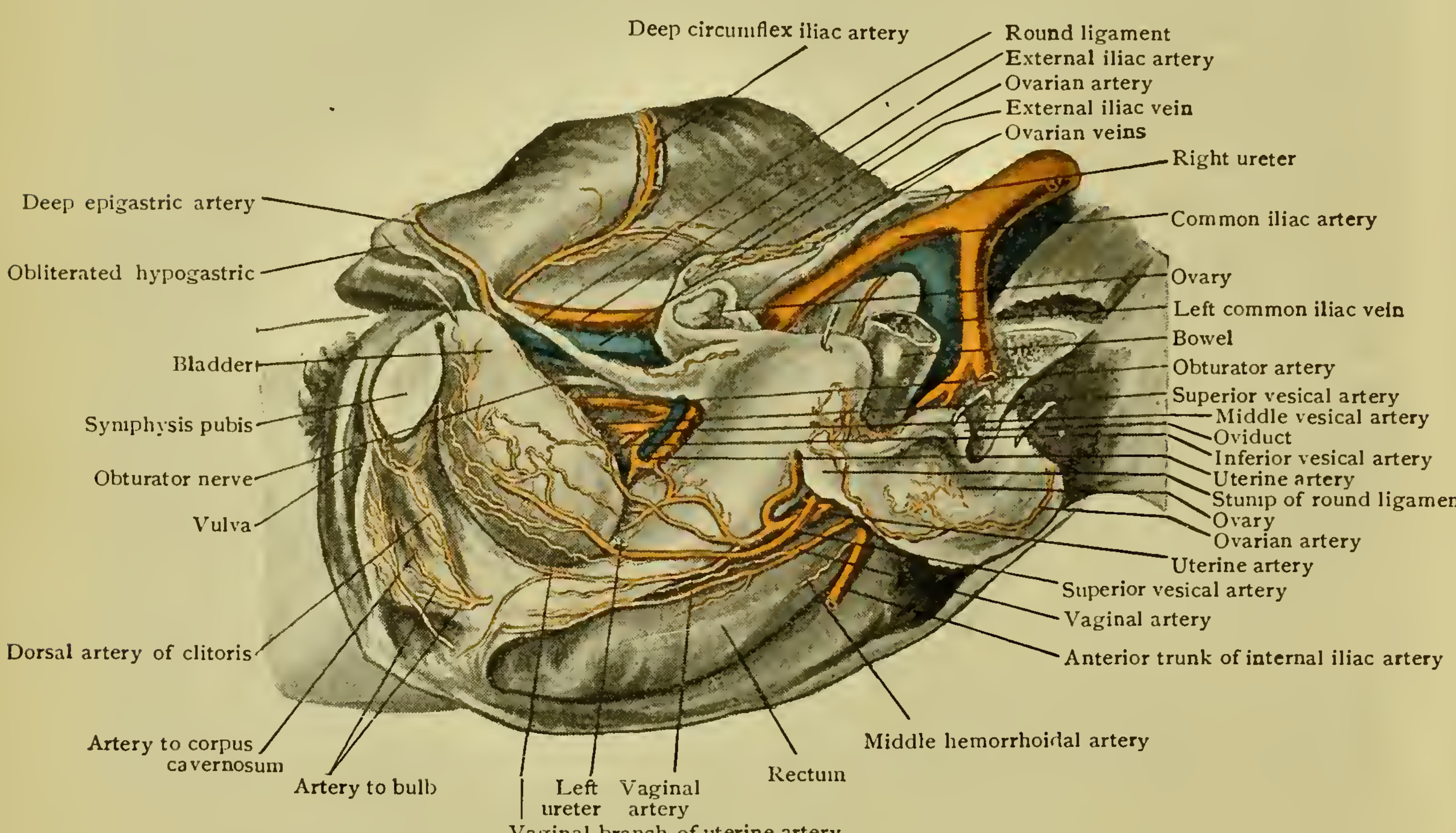

FIG. 341.—Arteries of female pelvis, seen from left side.

branches to the ovary. These latter should be exposed by incising one layer of the mesovarium. The **nerves** of the ovary, the ovarian plexus, reach it by the same route as the vessels and are branches of the aortic plexus. The **lymphatics** pass to the lumbar lymph-nodes.

The **ligament of the ovary, utero-ovarian ligament,** should be traced from the lower pole of the ovary into the broad ligament, and later, after separation of the layers of the latter, to the side of the uterus.

THE BROAD LIGAMENT.—The chief features of this ligament have been sufficiently indicated. It is only necessary to point out here its relation to the uterus and its attachment at its outer extremities to the lateral walls of the pelvis, as well as the fact that it divides the pelvic cavity into an anterior and a posterior compartment.

The **suspensory ligament of the ovary** should be noted as extending from the lateral part of the upper border of the broad ligament upward and outward over the external iliac vessels. If the **ovarian artery** be traced from its *origin* in the abdominal aorta, it will be found to enter the fibro-muscular mass of this ligament at or near the brim of the pelvis to reach the ovary. Since the suspensory ligament is covered by the peritoneum of the broad ligament, the latter must be cut along its upper margin and its layers separated to a sufficient extent to expose the artery and the suspensory ligament (Fig. 340).

The round ligament of the uterus, the ligament of the ovary and the vestigial structures (*vide infra*) within the broad ligament should be recognized at least by touch before further disturbing the broad ligament.

The *anterior layer* of the broad ligament should now be removed, the uterus being tilted backward and an incision being made along the upper margin of the uterus and of the broad ligament. The *subserous areolar tissue* between the folds and surrounding the uterus—the latter portion being the *parametrium*—is thus exposed.

The **uterine artery,** a branch of the anterior trunk of the internal iliac, should be followed from its entrance into the broad ligament beneath the lower border of the posterior layer to the side of the cervix, where it turns upward along the side of the uterus and then outward along the Fallopian tube to end by anastomosing with the ovarian artery. Its **branches** are a *ureteral branch* to the ureter as it crosses that duct before reaching the cervix; *cervical branches* to the cervix uteri and the vagina; *uterine*, *tubal* and *ovarian branches.*

The dissection of the *ovarian* and *tubal branches* of the ovarian artery should now be completed. The **ovarian** or **pampiniform plexus** of veins accompanying the ovarian artery and the large **uterine veins** are to be noted.

The **nerves** of the broad ligament which form an intricate network, the *utero-vaginal plexus*, originating from the pelvic plexus and from the second, third and fourth sacral nerves may be dissected; in many instances their dissection is difficult.

The **utero=ovarian ligament** (Fig. 342) should be identified and traced to the uterus.

The **round ligament of the uterus,** the vestige of the genito-inguinal ligament, should be followed from the lateral angle of the uterus outward to the pelvic wall, upward along this wall beneath the parietal peritoneum, over the external iliac vessels, and around the deep epigastric artery to the internal abdominal ring. Passing into and traversing the inguinal canal and the external ring, it terminates in the labium majus. This fibro-muscular band exerts some influence in maintaining the uterus in anteflexion; hence the operation of shortening the round ligaments to correct retro-displacement of the womb (Fig. 341).

The **vestigial structures** found between the layers of the broad ligament are the *epoophoron*, the *paroophoron* and the *stalked hydatid*. The **epoophoron (organ of Rosenmüller** or **parovarium)** is homologous with the epididymis of the male, being derived from the same series of Wolffian tubules and the same part of the Wolffian duct. Usually it consists of a larger tube to which are attached numerous smaller tubes at right angles to the larger one. It occupies a position near the ovary. It is of some clinical interest as being sometimes the seat of a cyst. The **paroophoron** on the inner side of the epoophoron corresponds with the paradidymis of the male, the structure being rudimentary in both

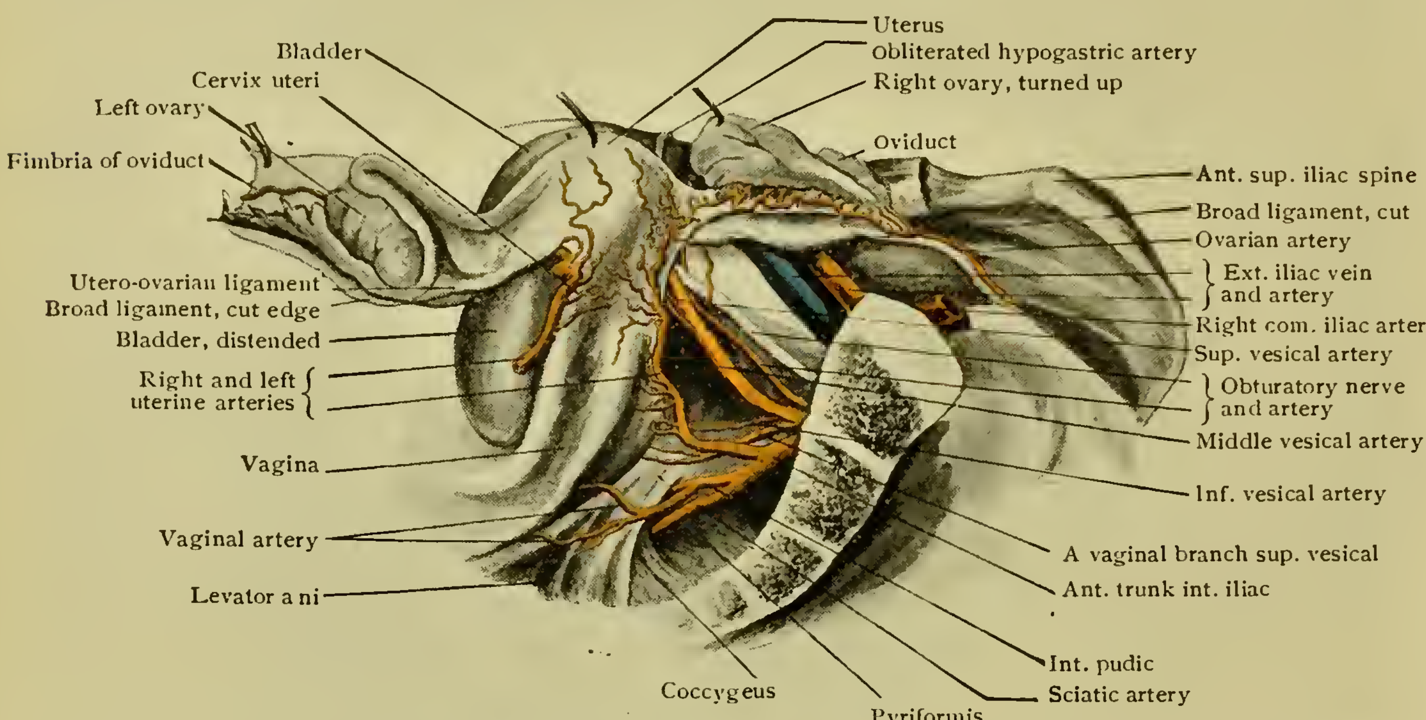

FIG. 342.—Dissection of female pelvis seen from the left. The left half of the pelvis has been removed.

sexes, and both being derived from the lower series of Wolffian tubules. The **stalked hydatid of Morgagni** which has its correspondence in the stalked hydatid of the male is derived like it from the upper end of the Wolffian duct (Fig. 343).

The **utero=sacral** and **utero=rectal ligaments** of the uterus are bands of muscular tissue passing from the isthmus backward to the sides of the rectum and the anterior surface of the sacrum respectively in the lateral portions of the pouch of Douglas, the **utero=rectal folds.** An effort should be made to discover them; they will be more accessible after the removal of one lateral wall of the pelvis. They are probably the agents most concerned in maintaining the position of the uterus.

A part of the left lateral wall of the pelvis may now be removed in the manner directed at page 691.

The examination of the previously inaccessible parts of the rectum, the uterus and the bladder should now be completed and the **pelvic plexuses** (p. 690) and the **obturator nerve** (p. 692) should be dissected.

The **pelvic blood-vessels** should be dissected as indicated at page 693. The **ovarian artery,** representing the male spermatic artery, has been examined (p. 708).

The **uterine artery** (Fig. 341), representing the male vesiculo-deferential artery, should be followed from its origin in the anterior trunk of the internal iliac or the superior vesical, downward and inward over the levator ani and across the ureter to the side of the neck of the uterus and then upward between the layers of the broad ligament. Its further course and branches have been dissected (p. 709).

The **vaginal artery** (Fig. 341), corresponding to the male prostatic artery, should be traced from its origin in the anterior division of the internal iliac—sometimes it arises in common with the inferior vesical or middle hemorrhoidal—to the side of the vagina, its numerous *branches* to this structure being noted. The *azygos vaginal arteries*, formed by the anastomoses of these branches, pass along the anterior and posterior surfaces of the vagina.

The **pelvic stage of the ureter** (Fig. 341) may now be examined, the duct passing from the pelvic brim downward and forward in front of the internal iliac vessels and then with the uterine artery to the side of the neck of the uterus, where it goes beneath this artery and passes along the lateral surface of the upper part of the vagina to reach the bladder.

The ureter, when distended by a calculus, may be palpated through the vagina through which such calculi may be removed. The proximity of the ureter to the uterine artery exposes it to the risk of inclusion in the ligature placed upon the vessel in the operation of hysterectomy, whether by the vaginal or the abdominal route.

The **parietal** and **recto-vesical layers of the pelvic fascia** should now be treated as directed at page 686; the modification of the latter as found in the male is that a part of it will be traced to the vagina.

The **sacral ganglia** and the **sacral nerves** receive the treatment outlined at pages 691 and 696. The pyriformis (p. 699), the obturator internus (p. 695), the coccygeus (p. 698) and the levator ani (p. 565) are to be dissected in turn.

The **walls of the bladder** are to be dissected as in the male (p. 699), the absence of a prostate gland being noted.

The **female urethra,** an inch and a half in length, will be found in close relation with the anterior surface of the vagina; its relation with the subpubic arch should be noted.

The **vagina,** embracing at its upper end the neck of the uterus (p. 576), should now be cleaned and its *outer fibrous tunic* demonstrated. Its **relations** are now apparent: *behind*, it is covered by the peritoneum above and is related here with the pouch of Douglas (p. 706); while between this area and the pelvic floor, it is closely related with the rectum, the *recto-vaginal septum* intervening; still lower, it is separated from the rectum by the perineal body (p. 576) and passes through the

triangular ligament; *in front*, in its upper fourth, it is connected with the bladder by loose areolar tissue in which are the ureters and some veins and below this, is in close association with the urethra; on each side are the vesico-vaginal venous plexus and Bartholin's gland (p. 579).

The uterus, with what is left of the broad ligament and its contained structures, the vagina, the rectum, the bladder and the urethra should now be removed from the pelvis. The blood-vessels having been divided, the fibres of the levator ani that are attached to the rectum and vagina should be severed and a knife should be passed along the rami of the pubes and ischia of each side to cut the triangular ligament.

The **interior of the bladder** should now be studied as directed at page 699, the incision which opens it being prolonged along the upper surface of the entire urethra.

The **interior of the urethra** shows slight longitudinal folds of the *mucosa* and, on the proximal half of the posterior wall, the *urethral crest*, continuous with the apex of the trigonum vesicae. If the mucosa be removed, the *inner longitudinal layer of muscle* will be exposed; external to this are the *outer circular muscular fibres* continuous with those of the bladder to form the internal sphincter; a connective tissue layer between the two muscular strata contains a plexus of veins. The relation of the canal to the triangular ligament and the compressor urethræ has been seen (p. 579).

The elastic tissue of the mucosa and the exterior relations of the female urethra make it readily dilatable, so that vesical calculi or foreign bodies of comparatively large size may be extracted through it.

The **vagina** should be rather tightly stuffed and an effort made to dissect off the *outer fibrous tunic* to demonstrate the outer longitudinal and inner circular strata of the *muscular tunic*. The continuity of the muscular coat with the uterine muscle and its connection near the vaginal orifice with the compressor urethræ and the bulbo-cavernosus (sphincter vaginæ) should be made out (p. 578). A median incision through the anterior wall will expose the *mucosa*, the rugæ of which have been noted (p. 576).

Congenital anomalies of the vagina include its *absence*, its *arrested development* and *double vagina*, the latter resulting from imperfect fusion of the lower ends of the Müllerian ducts. Exaggerated contraction of the sphincter, due to general or local causes, may be so extreme as to render coitus painful or to prevent it.

The **broad ligaments of the uterus** should be spread out and pinned down and the dissection of their contents (p. 710) completed.

The **uterus** (p. 706) may now be examined more particularly as to its relations to the vagina, the oviducts and the ovarian and round ligaments. The *muscular coat*, *myometrium*, is exposed upon the removal of the *serous coat* or *perimetrium*. The thin outer longitudinal fibres, seen upon the fundus and body, are continued to the oviducts

and to the various ligaments. A probe or director should be passed into the uterine cavity through the external os to serve as a guide in making a coronal section, which may be effected by passing a knife along the probe with its edge directed toward one side of the uterus and cutting from within outward, repeating the procedure on the opposite side. The uterine cavity as now exposed (Fig. 343) is seen to be spindle-shaped in the cervix—in the nulliparous uterus—the two ends of the spindle being respectively the *internal* and the *external os*, while it presents a triangular outline in the body, expanding from the internal os to its greatest width just below the openings of the oviducts. The mucosa appears smooth in the body but is rugose in the cervical canal,

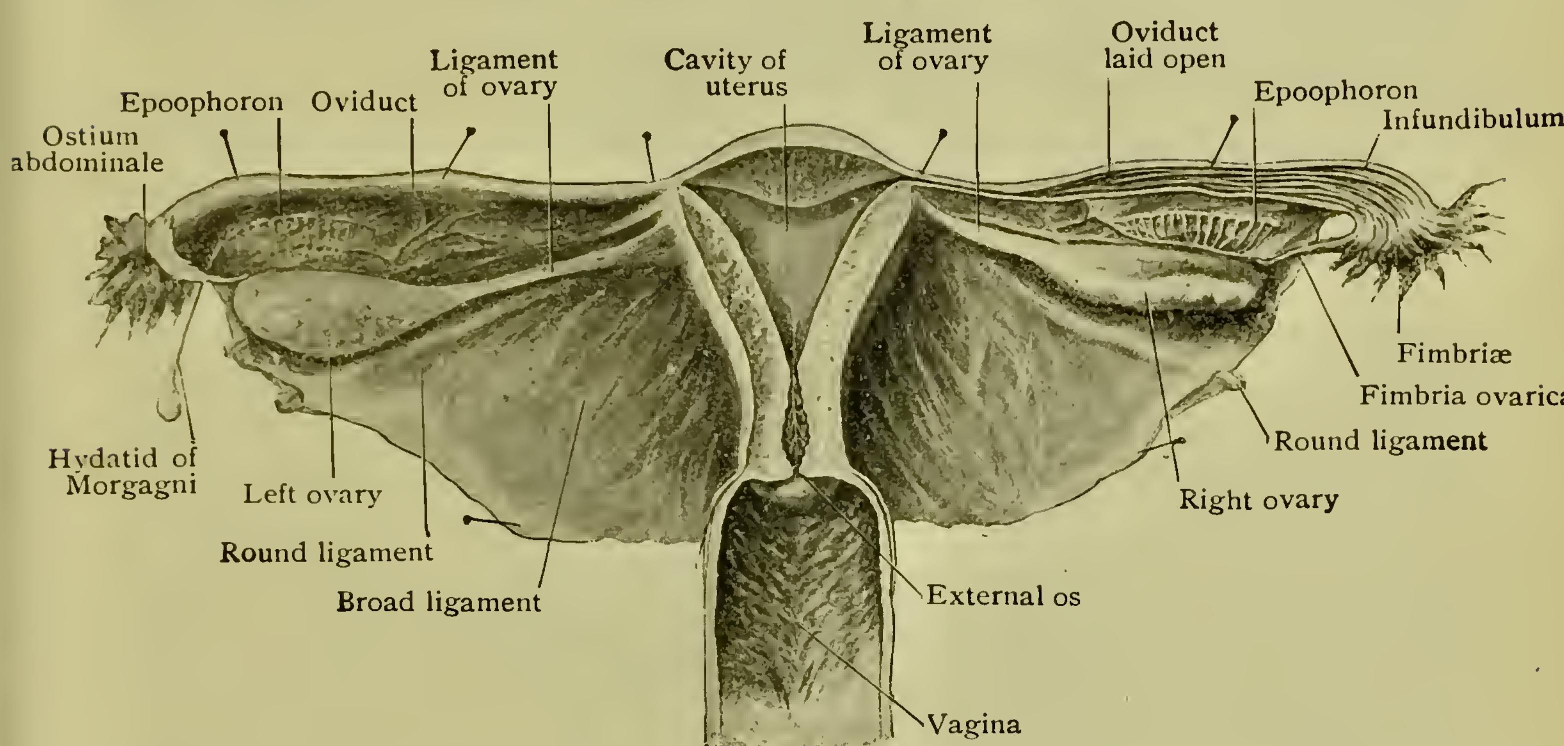

FIG. 343.—Broad ligaments, viewed from behind, have been stretched out and pinned, the posterior wall of uterus and vagina removed and right oviduct laid open. Ovaries do not occupy their normal position, their long axes here being horizontal instead of approximately vertical.

the folds, *plicae palmatae* or *arbor vitae*, seen here including an anterior and a posterior median ridge from which diverge smaller folds. A portion of the mucosa should be reflected to demonstrate the absence of a submucosa and the great thickness of the muscular coat.

The uterus being supported in part by the attachments of the utero-sacral ligaments to its isthmus and the latter being its weakest part, forward or backward **flexions** may occur at this point especially if, for any reason, the body of the organ be unduly heavy. The agency of the round ligament in maintaining the physiological degree of anteflexion has been noted. A normal condition of the perineal body and of the levator ani are other important factors in the support of the uterus. Descent, anteflexion and retroflexion are favored by any weakening of the support or by increase in weight of the organ or by both; hence the frequency of uterine displacements in unrepaired lacerations of the perineum, especially when associated with subinvolution.

Defective union of the Müllerian ducts in varying degree results in either *uterus bicornis* or *double uterus*.

THE THORAX.

The thorax should be studied in the articulated skeleton. Its **boundaries** are seen to be, posteriorly, the thoracic vertebræ and the proximal portions of the ribs; at the sides and, in part, in front, the remaining portions of the ribs and their cartilages, being completed in front by the sternum. The obliquity of the ribs should be noted as well as the failure of the eleventh and twelfth ribs to contribute to the anterior wall of the cavity.

The spaces between the ribs, the **intercostal spaces,** are noteworthy as being wider in front than behind and wider in the upper than in the lower part of the chest, the third space being widest, the second, first, fourth and fifth ranking next in the order named.

The **superior aperture of the thorax** will be seen to be formed by the first thoracic vertebra, the first pair of ribs and the manubrium of the sternum, the opening being encroached upon by the sternal ends of the clavicles.

The important structures which pass through this opening, such as the trachea, œsophagus, pleuræ, apices of the lungs, innominate, left common carotid, left subclavian and internal mammary arteries, the innominate veins and the vagus, phrenic, recurrent laryngeal and cardiac nerves will be encountered during the course of the dissection.

The very irregular **inferior aperture** of the thorax is to be noted as being enclosed by the last thoracic vertebra, the last pair of ribs, the ends of the eleventh ribs, the obliquely directed cartilages of the sixth to the tenth ribs inclusive and the lower end of the sternum. While this opening is closed by the diaphragm, to which its margins give attachment, the dome-like form of this muscular septum is to be born in mind in estimating the vertical limits of the thoracic cavity.

The chief **contents** of the thorax are the lungs, each enclosed in its own sac of serous membrane, the pleura, the heart, enclosed in the pericardium, the great vessels connected with the heart, and certain smaller vessels and nerves.

THE SURFACE ANATOMY.

The surface anatomy of the thorax is noted at pages 11 and 28.

DISSECTION.

The integument and fascia and the thoracic attachments of those muscles connecting the thorax with the upper limb having been removed by the dissector of the upper limb, the intercostal spaces are to be examined and their contents dissected.

Intercostales Externi.—An external intercostal muscle is found in each intercostal space; hence there are eleven pairs. **Origin,** the lower border of the shaft of the rib above; **insertion,** after passing down-

ward and forward, the upper border of the shaft of the rib below; **action,** to elevate the rib; **nerve-supply,** the corresponding intercostal nerve. In the lower spaces, the muscles are attached also to the costal cartilages.

The *external intercostal fascia* or *anterior intercostal membrane* occupies the intervals between the anterior borders of the muscles and the sternum.

The **lateral cutaneous branches of the intercostal nerves** (p. 33) and the **lateral cutaneous branches of the intercostal arteries** should

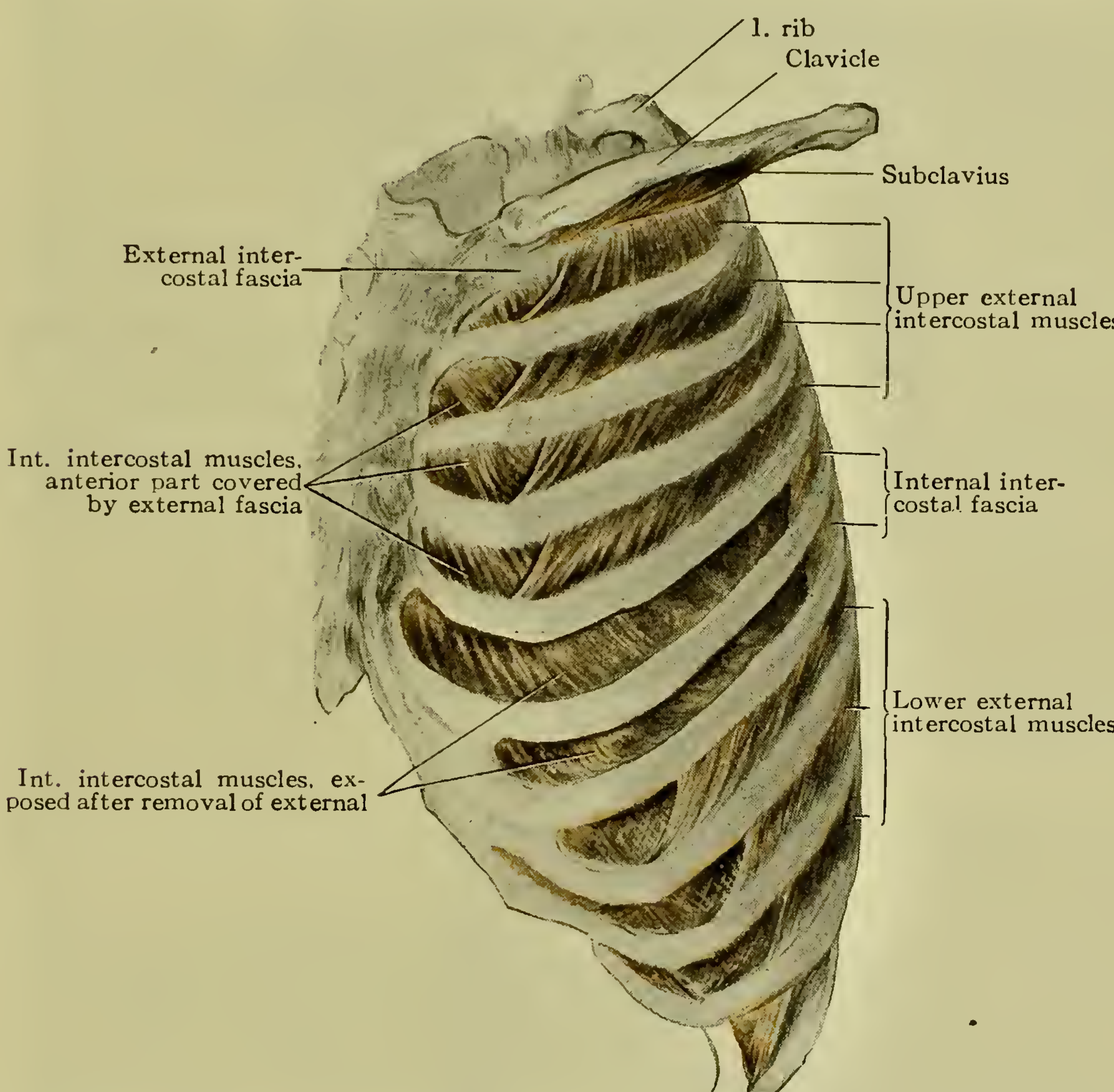

FIG. 344.—Dissection of thoracic wall of left side, showing intercostal muscles and fasciæ.

be identified as they come through the muscles in approximately the anterior axillary line, and also the **anterior perforating branches** of the **internal mammary artery** (Fig. 20), which are found near the sternum in the five or six upper intercostal spaces, as they emerge in company with the **anterior cutaneous branches** of the **intercostal nerves.** There is no lateral and usually no anterior cutaneous branch of the first nerve (*vide* p. 33).

The fascia, sometimes called the *external intercostal fascia*, should now be removed from a few of the external intercostal muscles and the mingling of tendinous or aponeurotic fibres with the muscular fibres noted.

The external intercostal muscles that have been exposed should now be cautiously cut and reflected or removed and the intercostal nerves and vessels sought.

The **anterior intercostal branches of the internal mammary artery** will be found beneath the external intercostal muscles, in the spaces above the sixth, each vessel dividing into a larger *upper* and a smaller *lower branch*, which pierce the intercostal muscles and anastomose with the aortic intercostal arteries and the intercostal branches of the superior intercostal artery.

The **intercostal branches of the superior intercostal** in the first and second spaces and the **intercostal branches of the thoracic aorta** in the remaining nine spaces will be found, one in each space, in the subcostal groove on the lower border of the upper rib and therefore hidden from view. The corresponding **intercostal nerve** is below the artery, but in the anterior half of the interspace the nerve is within or beneath the internal intercostal muscle. The **vein** in each case is above the artery. The three structures may be gently pulled downward with a blunt hook. The *collateral branch of the artery* will be found along the upper border of the lower rib of the space.

The intercostal arteries may be torn in fractures of the ribs, the blood sometimes finding its way into the chest cavity. The difficulty of tying the artery will be appreciated in noting its relations as indicated above, resection of a rib being sometimes necessary to gain access to it.

The **middle intercostal fascia** should now be removed from the internal intercostal muscles.

Intercostales Interni.—These muscles correspond in *number*, *attachments*, *action* and *nerve-supply* with the external intercostals (*vide supra*) but are placed farther forward, extending from the angles of the ribs to the margin of the sternum. Their fibres, moreover, pass downward and backward. The *posterior intercostal membrane* or *internal intercostal fascia* is found between the posterior borders of the muscles and the tubercles of the ribs.

The **intercostal nerves,** the ventral divisions of the thoracic nerves—the first intercostal is only a part of the ventral division of the first thoracic nerve—should now be traced from their entrance into the internal intercostal muscles midway between the spine and sternum, to the anterior ends of the spaces, their *cutaneous branches* (p. 715) and their *muscular branches* to the intercostal muscles being noted; the lower six have been followed to the abdominal wall (p. 599).

THE CAVITY OF THE THORAX.

The Internal Mammary Artery.—This vessel, a branch of the subclavian (p. 384), should be sought in the intercostal spaces a finger's breadth from the margin of the sternum, as it passes downward beneath the costal cartilages to divide, opposite the sixth interspace, into its

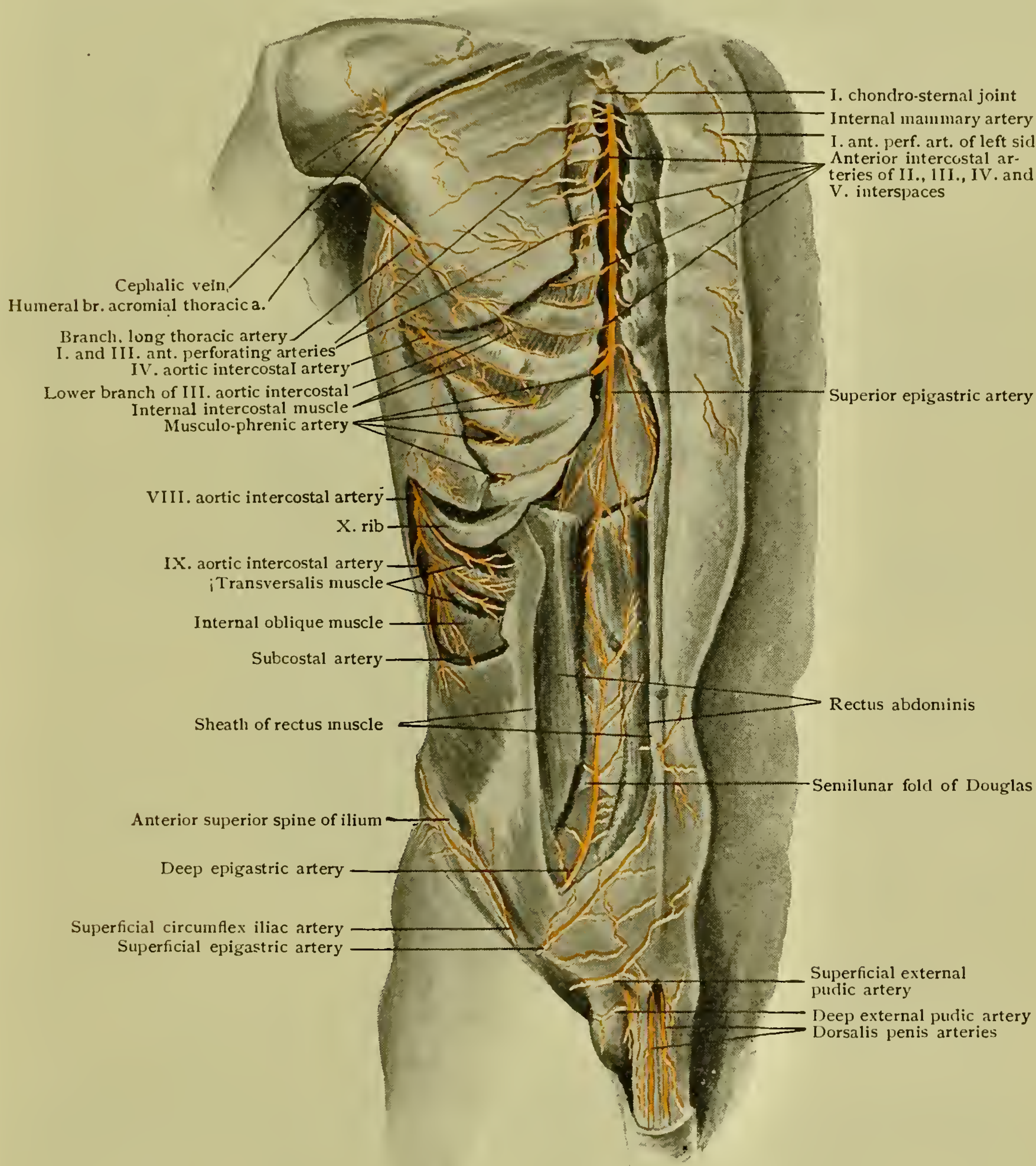

FIG. 345.—Internal mammary and deep epigastric arteries.

terminal branches, the *musculo-phrenic* and the *superior epigastric arteries*. Of its **branches,** the *anterior perforating*, the *anterior inter-*

costals (p. 716) and the *superior epigastric* (p. 614) have been dissected; the *superior phrenic* and the *mediastinal* will be seen later (p. 721).

The **musculo-phrenic** may be followed downward and outward beneath the seventh and possibly the eighth cartilage, where it perforates the diaphragm, after which it continues as far as the eleventh rib. This vessel and the parent trunk can be more fully examined later.

The Parietal Pleura.—The parietal layer of the pleura, lining the chest-cavity, is reflected from the anterior wall on the *right side* in a line extending from the right sterno-clavicular joint downward and inward to the mid-line of the upper end of the meso-sternum, thence vertically downward to the ensiform, from which point it slopes out-

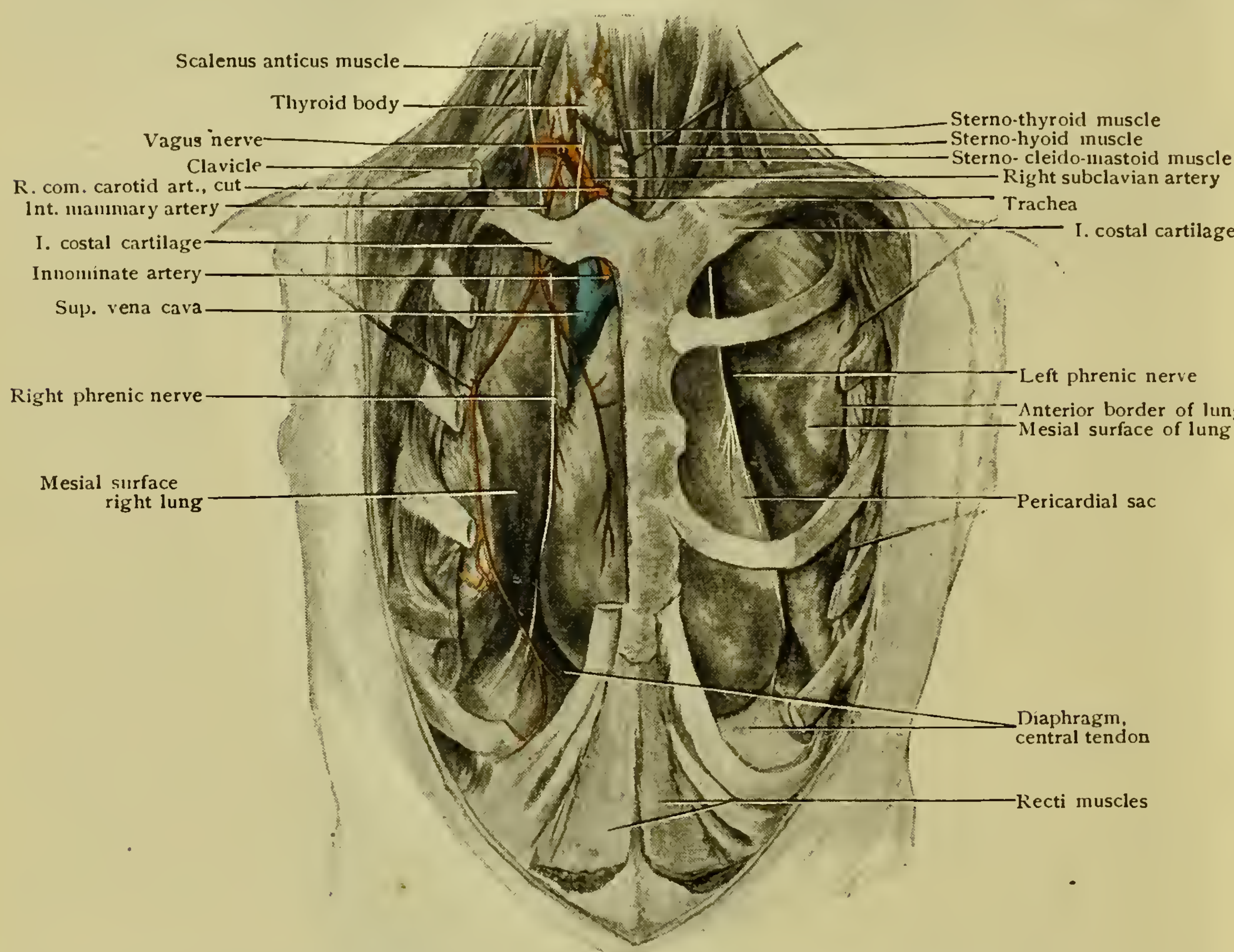

FIG. 346.—Anterior thoracic wall has been partly removed, leaving left half of sternum and some ribs in place; lungs have been drawn aside to expose pericardial sac.

ward across the deep surface of the seventh costal cartilage; the line of reflection on the *left side* extends from the left sterno-clavicular joint downward and inward to the middle of the top of the meso-sternum, thence vertically downward to the level of the fourth costal cartilage from which point it deviates to the left and passes downward a little to the left of the sternum to the sixth costal cartilage. The student will do well to indicate these lines on the skeleton with crayon or on the cadaver with a blunt instrument or an aniline pencil. The parietal

pleura will be partially exposed by removing the muscles from the intercostal spaces—separating them cautiously from the pleura—then more completely by removing the second and the fourth ribs of both sides after having separated the pleura from them with the finger, having cut the cartilages at their junction with the ribs and having divided the ribs with bone forceps slightly in advance of their tubercles.

The **pericardium,** containing the heart, should now be noted as being exposed where the right and left lines of pleural reflection diverge at the level of the fourth cartilage. The *apex* or left lower extremity of the **heart** may be noted, by palpation and then by displacing the left pleura, to correspond with the fifth interspace three and one fourth inches from the median line, while its *base* is indicated by a line extending from the upper border of the third right costal cartilage one and one fourth inches from the mid-line to a point just above the third left cartilage one and three fourths inches from the mid-line. The *left border* of the heart will be defined by a line convex toward the left drawn from the left end of the base-line to the apex, while the *right border* will be indicated by a line convex toward the right extending from the right end of the base line to the union of the seventh cartilage with the sternum, and the *lower border* by a line connecting the latter point with the apex. The third, fifth and sixth ribs may now be removed.

The *posterior line of pleural reflection* may now be noted as being, for each side, the lateral aspect of the spinal column. Passing the fingers between the pleura and the necks of the ribs and separating it from these and from the spine, the posterior mediastinal space will be penetrated.

The *line of diaphragmatic reflection* of the pleura, or the line along which it is reflected from the costal wall of the thorax to the diaphragm, may also be followed. This line, on the *left side*, crosses the sixth and seventh costal cartilages, the junction of the eighth rib with its cartilage, the extremities of the ninth and tenth ribs, the tenth interspace—this being the lowest limit of the pleura—then, inclining upward, passes across the eleventh and twelfth ribs to reach the spine about midway between the transverse process of the first lumbar vertebra and the head of the last rib. On the *right side*, the reflection-line is lower in front, beginning behind the seventh costal cartilage. (See Fig. 362).

The level to which the pleura descends behind exposes it to injury in the lumbar operations upon the kidney if the incision in such operations is carried above the level of the first lumbar transverse process.

The Mediastinum.—The pleura of each side forms a closed sac, the inner or **visceral layer** of which is closely applied to every part of the surface of its lung except at the hilum or place of attachment of the root of the lung, while the **parietal layer** lines the chest cavity.

Since the heart, the great vessels, the trachea, œsophagus and certain nerves occupy the part of the thoracic cavity adjacent to the mesial plane, the two pleural sacs are separated from each other by these structures and the latter are contained within a region, the *mediastinum* or *mediastinal space*, bounded on each side by the corresponding pleural sac. The parietal layer of each sac as it leaves the anterior chest wall along the anterior reflection line (*vide supra*) passes backward to the root of the lung as the **mediastinal pleura,** since it constitutes the lateral boundary of the mediastinum. Reaching the anterior surface of the root of the lung, it becomes continuous with the visceral layer.

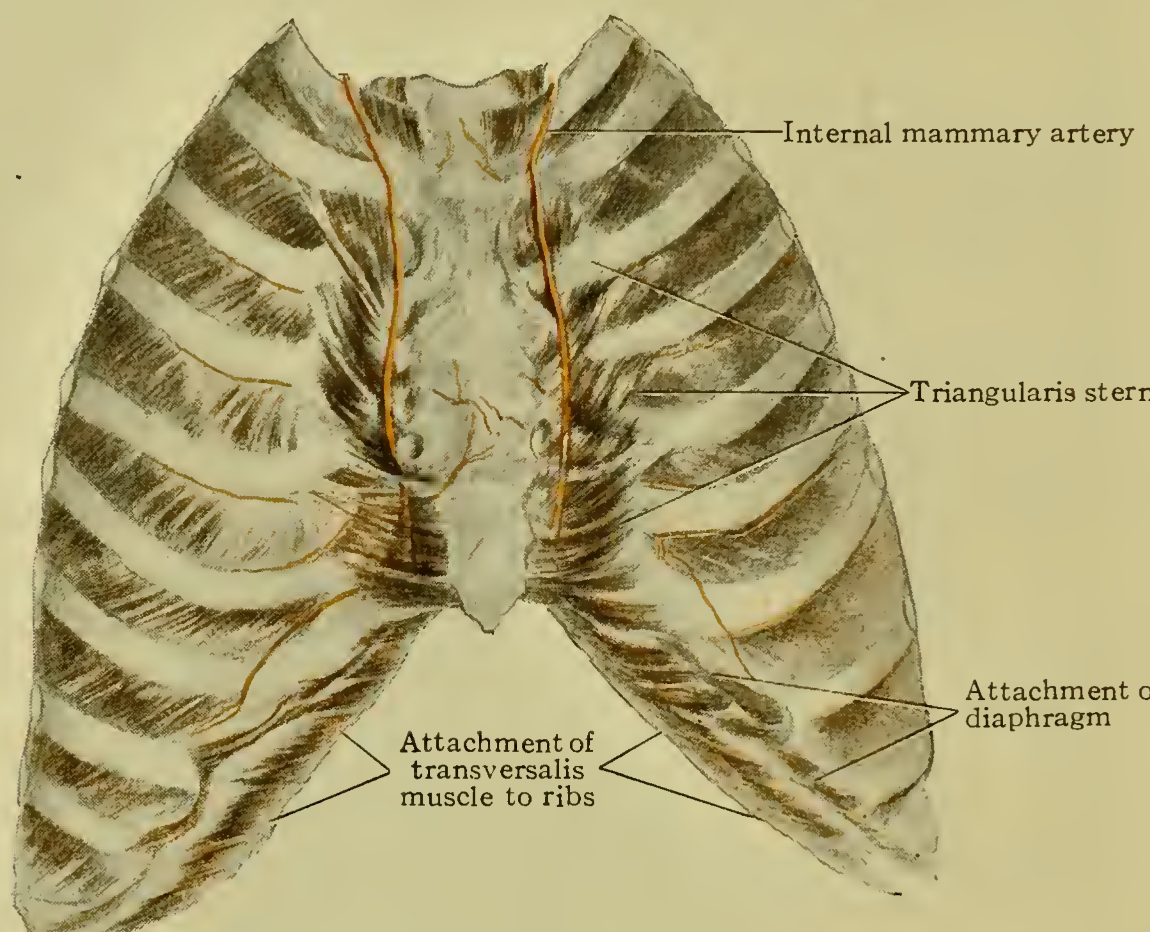

Fig. 347.—Dissection of anterior thoracic wall from behind, showing triangularis sterni and intercostal muscles.

The parietal pleura posteriorly leaves the spine to pass forward as another portion of the mediastinal pleura to reach the root of the lung and there become continuous with the visceral pleura. Both the costosternal and the mediastinal parts of the pleura are continuous below with the **diaphragmatic pleura.**

The sternum should now be sawn transversely between the articulations of the first and second pairs of cartilages and also between the attachments of the fifth and sixth pairs, with care to avoid laceration of the subjacent soft tissues in completing the section. The third and fifth costal cartilages of each side should be cut at their union with the ribs. Cautiously elevating the part of the sternum between the

saw-cuts, note the attachments of the **superior** and **inferior sterno-pericardiac ligaments** respectively to the manubrium sterni and to the ensiform cartilage. Upon severing these ligaments and removing the sternum, the anterior and superior mediastini are exposed.

The **triangularis sterni muscles** (Fig. 347) should now be examined, their **origin** from the deep surfaces of the second or third to the sixth or seventh costal cartilages and their **insertion** into the margins of the gladiolus and xiphoid process being noted. Their **nerve-supply** is the corresponding thoracic nerves. The internal mammary artery in relation with the anterior surface of the muscles should also be noted.

The Anterior Mediastinum.—This subdivision of the mediastinal or inter-pleural space is now seen to lie behind the sternum between the pleuræ and, if the pleuræ be separated, in front of the pericardium. It contains loose areolar tissue and a few lymph-vessels and nodes, and in the infant and rarely in the adult, a part of the thymus gland.

The Superior Mediastinum.—This portion of the interpleural space is above the upper level of the pericardium and is bounded in front by the manubrium and behind by the upper four thoracic vertebræ. Its *contents* are the upper half of the superior cava, the innominate veins and left superior intercostal vein; the arch of the aorta, the innominate and the thoracic parts of the left common carotid and left subclavian arteries; the vagus, left recurrent laryngeal, phrenic and cardiac nerves; the trachea, œsophagus, thoracic duct, remains of the thymus gland and lymph-nodes; the lower parts of the longus colli, sterno-hyoid and sterno-thyroid muscles. These structures will be dissected as directed below (Figs. 350 and 362).

The Middle Mediastinum.—This portion of the mediastinal space contains the pericardium enclosing the heart, the ascending aorta, the lower half of the superior cava and the termination of the vena azygos major, the pulmonary artery, the bifurcation of the trachea, the phrenic and vagus nerves, the roots of the lungs and some bronchial lymph-nodes.

The **phrenic nerves** (p. 357) are to be exposed by separating the mediastinal pleuræ from the pericardium, each nerve crossing the beginning of the internal mammary artery and reaching the front of the root of the lung and being accompanied by the *superior phrenic artery* (a. comes nervi phrenici) (p. 718). The *right nerve* passes to the right of the innominate vein and the superior cava, while the *left* crosses the vagus and the aortic arch. The nerves should be traced downward to the diaphragm which they pierce and to which they are distributed. They give a few *branches* to the pleura and pericardium (Fig. 362).

The **roots of the lungs** are to be examined from in front by pulling the lung outward and the pericardium inward. The *anterior pulmonary plexus* (from the sympathetic and vagus) and the *phrenic nerves* are in relation with their front surfaces, the root of the right lung being partly

behind the ascending aorta. The *pulmonary veins*, usually two for each lung, but sometimes irregular in this respect, form the most anterior part of the root of the lung and are to be exposed by stripping the pleura, without tearing it, toward the lung. The *pulmonary arteries*—the artery of each side usually divides into two branches just before entering the lung—lie posterior to and somewhat above the veins. Both veins and arteries should be traced to the pericardium. The *bronchi*, placed behind the arteries, should be exposed to as great extent as possible at this stage (p. 738, Fig. 350).

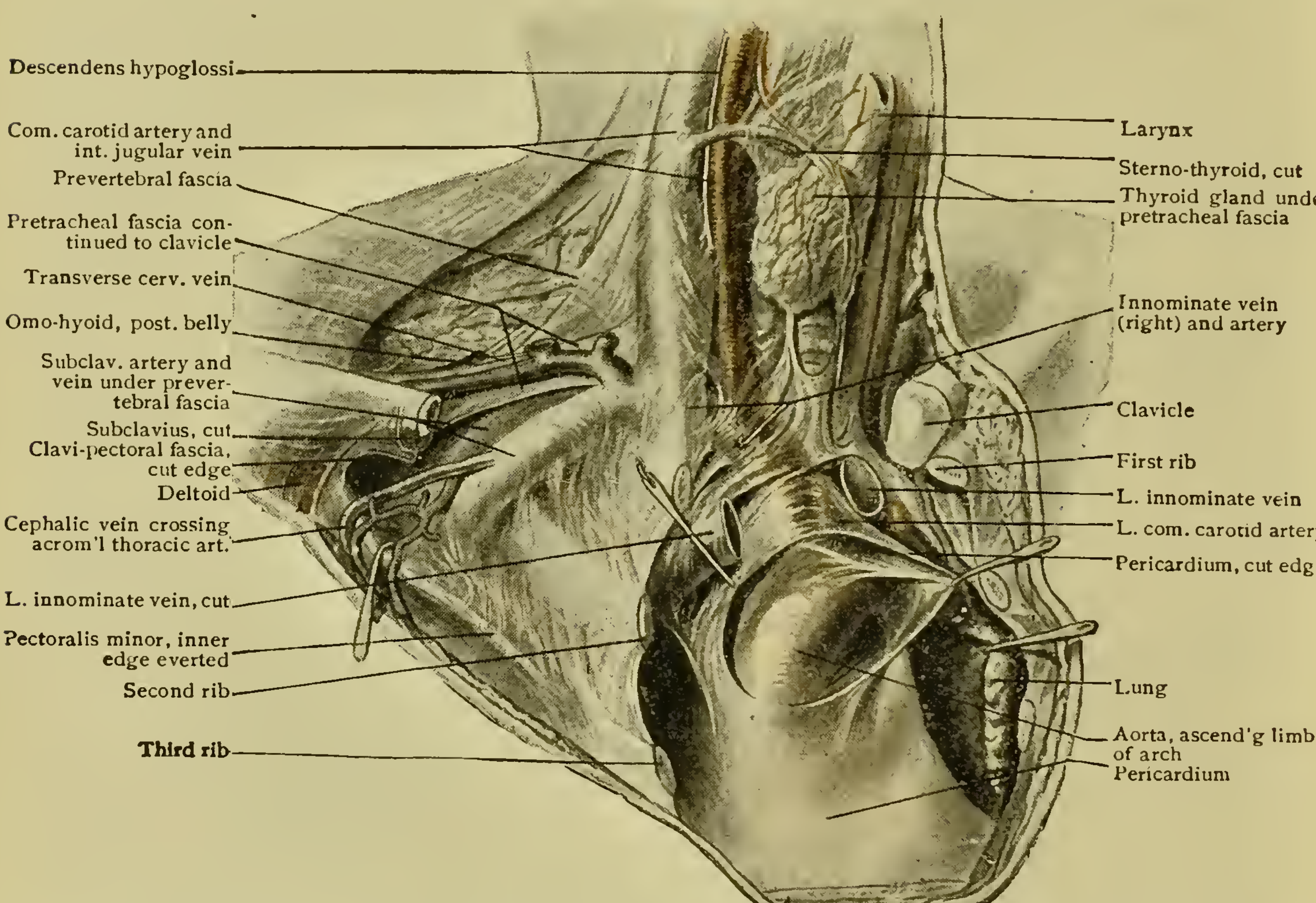

FIG. 348.—Deep cervical fascia, pretracheal and prevertebral layers. Sternum and part of right clavicle have been removed, a part of left innominate vein excised and an opening made in the pericardium. The continuity of the prevertebral fascia with the clavipectoral fascia on the deep surface of the lesser pectoral muscle is shown.

The Pericardium.—The extent to which the pericardium is related with the thoracic wall has been seen (pp. 719 and 721). If the hand be passed downward between it and the pleura, it will be found to be attached by its broad *base* to the diaphragm so loosely as to be easily separated from it except near the mid-line. The exploring hand will come upon the inferior vena cava where the latter passes through the quadrate opening to reach the right auricle and upon the root of the lung on each side. The *apex* of the pericardium is continuous over the great vessels (Fig. 348) with the pretracheal fascia (p. 361).

The pericardium should now be opened by a vertical incision beginning on the front of the aorta to which should be added a transverse incision at the level of the roots of the lungs. The outer *fibrous layer* being now reflected, the *serous layer* is exposed. The **fibrous pericardium** is now seen to enclose all the vessels connected with the heart—the

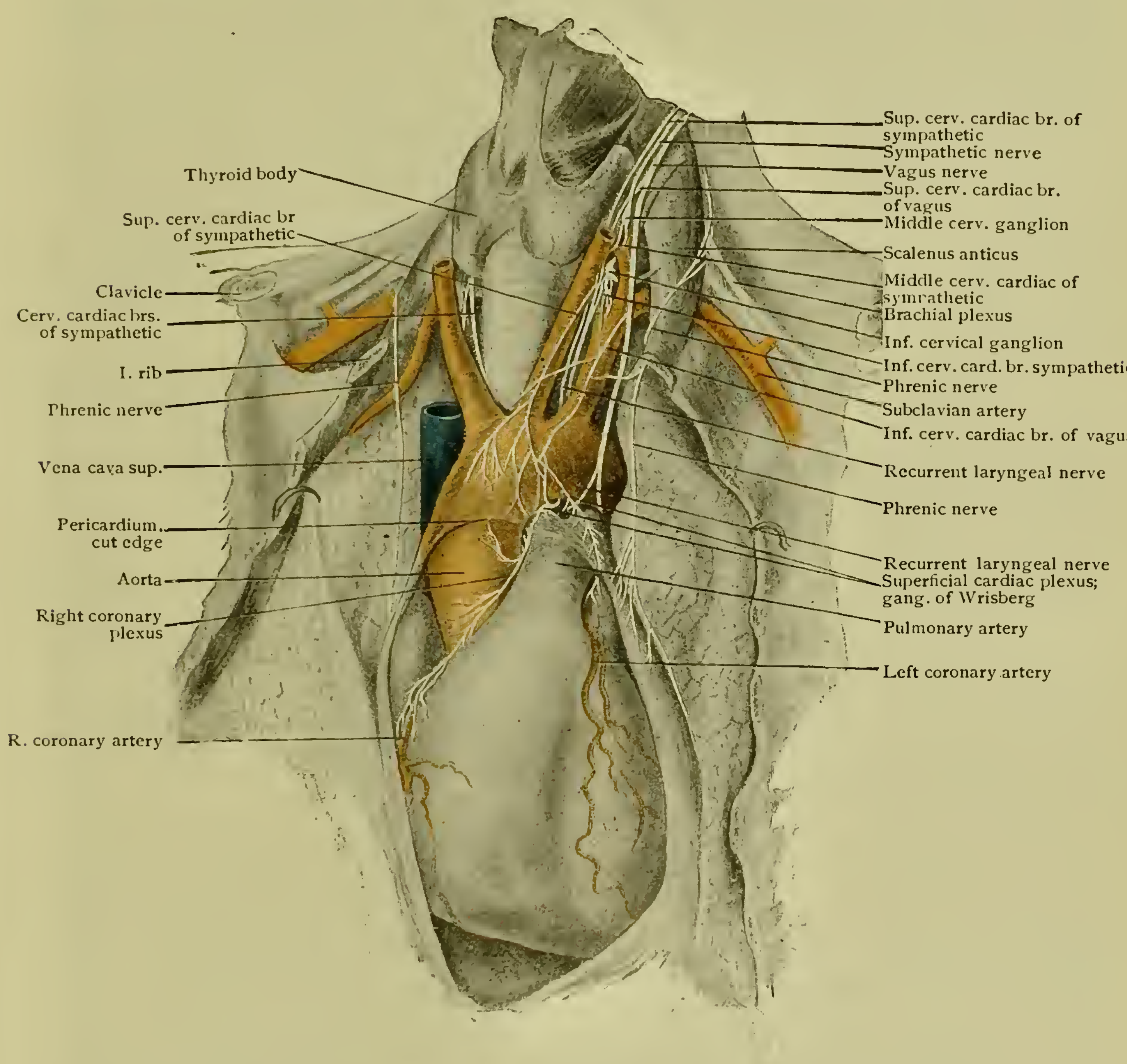

FIG. 349.—Dissection showing constituents of superficial cardiac plexus, other cardiac nerves and right coronary plexus. The right cervical cardiac branches of the sympathetic are united into one trunk.

ascending aorta and the pulmonary artery for their entire length—except the inferior vena cava which terminates in the right auricle immediately after piercing the diaphragm. The *parietal part* of the **serous layer** is reflected from the deep surface of the fibrous layer upon the great vessels (Fig. 349) to become the visceral layer, *epicardium*, as it passes from the

vessels to the surface of the heart. Passing the hand around the heart within the pericardial cavity, it will be seen that the heart is free from connection with the pericardium except at the attachments of the vessels. The serous membrane invests the aorta and the pulmonary artery in a common sheath and covers the pulmonary veins and the superior cava on the front and sides, the posterior surfaces of these vessels being in contact with the fibrous layer. A finger passed transversely behind the aorta and pulmonary artery, between them and the right auricle, enters the *transverse sinus* of the pericardium. The *oblique sinus*, between the posterior surface of the left auricle and the fibrous pericardium, may be demonstrated by pulling the apex of the heart upward and forward, when the orifice of the sinus will be seen between the right and left pulmonary veins. The **vestigial fold of Marshall** may be seen as a serous fold between the left pulmonary artery and the upper left pulmonary vein; it is of interest as containing the impervious remnant of a part of the left superior cava of the fetus.

Inflammation of the pericardium, *pericarditis*, produces roughening of the serous layer, which causes a friction sound as the heart moves within the pericardium; *pericardial effusion* may also occur and when of sufficient degree to embarrass the heart action necessitates evacuation of the fluid by a needle-puncture (paracentesis pericardii) or preferably by open incision, with resection of the fifth left costal cartilage.

The Posterior Mediastinum.—The body may be turned to give opportunity for inspection of the posterior mediastinum, which is bounded on either side by the mediastinal pleura, behind by the thoracic vertebræ below the fourth, in front by the pericardium and the roots of the lungs. The *contents* of this space are the descending thoracic aorta, the greater and lesser azygos veins, the vagus and splanchnic nerves, the thoracic duct and some lymph-nodes, and the œsophagus. They will be dissected later.

The Superior Vena Cava (Fig. 350).—Traced from its **origin,** opposite the first right costal cartilage in the union of the two innominate veins, this vessel is seen to **terminate** in the upper posterior angle of the right auricle and to have a length of two and one half to three inches. It is **related** *in front* with the pericardium in its lower half and with the upward continuation of the fibrous layer of that sac in its upper half, by which it is separated from the thymus gland and the sternum; on its *right* side, with the phrenic nerve; on the *left*, with the ascending aorta and the origin of the innominate artery; *behind*, with the root of the right lung. Its chief **tributary,** the vena azygos major, should be found arching forward over the root of the lung to open into the superior cava just before the latter pierces the pericardium. The cava may be slit, at a later stage, to demonstrate the absence of valves.

The Innominate Veins (vv. anonymae dextra et sinistra).—Exposure of these veins will show the **origin** of each to be the union of the internal

jugular and subclavian of its own side, behind the inner end of the clavicle (Fig. 350). The **right vein,** an inch long, is *related in front* with the pleura, *behind and on the left* with the innominate artery, and *on the right* with the phrenic nerve. The **left vein,** two and one half inches long, runs downward and to the right to meet its fellow. It is *related in front* with the downward prolongation of the pretracheal fascia, the manubrium sterni and the remains of the thymus gland; *below*, with the aortic arch; *behind*, with the innominate, left common carotid and

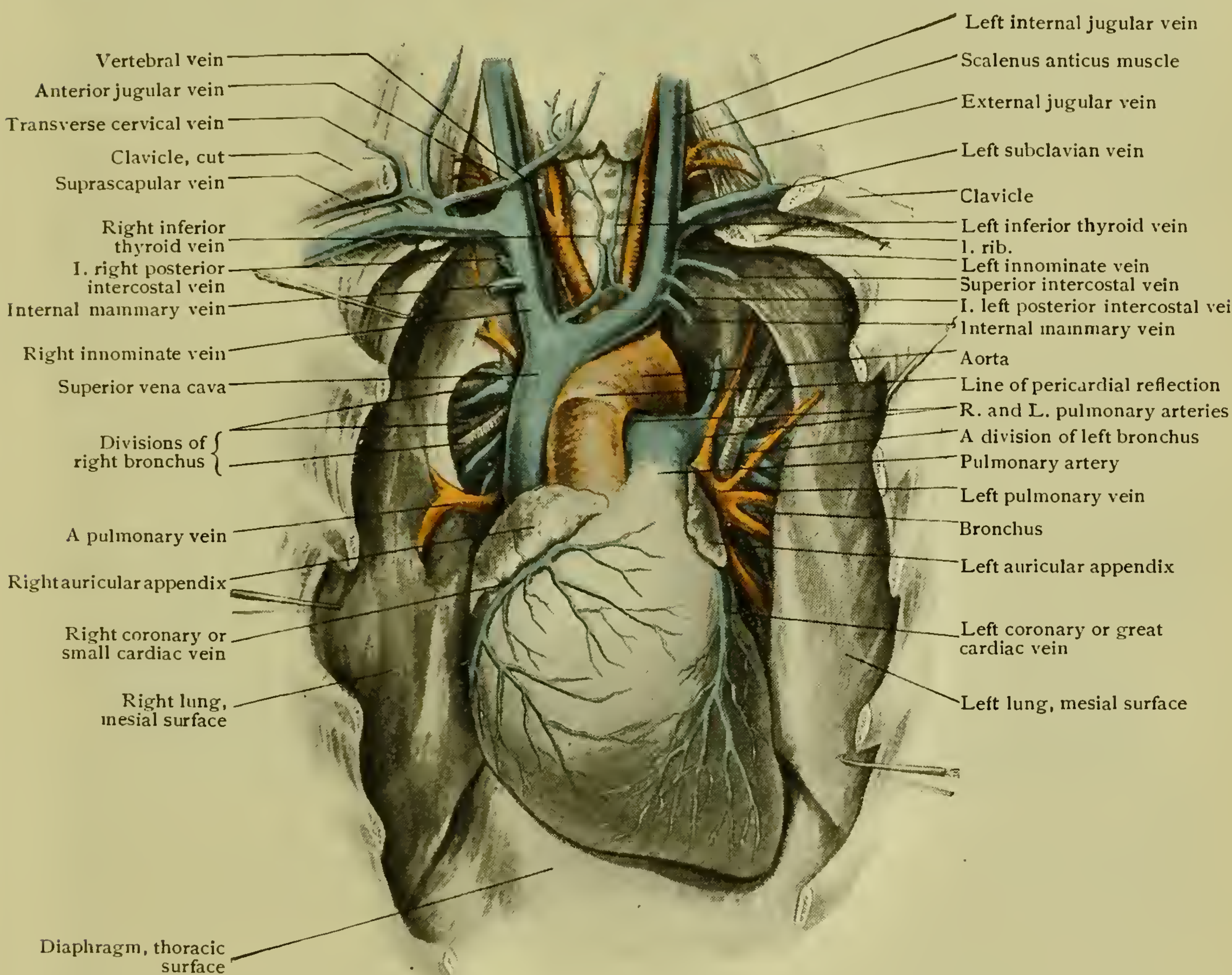

FIG. 350.—Dissection showing innominate veins and superior vena cava in position; lungs have been pulled aside.

left subclavian arteries. The **tributaries** of each of these veins are the vertebral, inferior thyroid, internal mammary and superior intercostal veins of its own side; the right superior intercostal, however, usually drains into the vena azygos major.

THE ARCH OF THE AORTA (Fig. 350).—The ascending portion of the arch, two inches in length, has been seen to be enclosed for an inch and a half in the pericardium (p. 723). It should now be denuded, the line of reflection of the serous pericardium being noted, and followed to its **origin** at the base of the left ventricle, behind the third left chondro-

sternal joint, where it is overlapped by the pulmonary artery on the left and the right auricular appendix on the right. Passing upward and to the right, it becomes continuous with the transverse portion at the level of the upper border of the second right costal cartilage. It is **related** *in front* at its root with the pulmonary artery and the right auricular appendix and in the greater part of its extent with the pericardium, the pleura and the margin of the right lung; *on the right*, with the right auricle and superior cava; *on the left*, with the pulmonary artery; *behind*, with the left auricle, the right pulmonary artery and the right bronchus. Its **branches** are the *right* and *left coronary arteries* (pp. 728 and 729); the *right artery* may be traced to its origin, the anterior sinus of Valsalva.

The **transverse portion of the arch,** extending from the second right costal cartilage obliquely across to the left side of the fourth thoracic vertebra should be carefully exposed and cleaned, the nerves upon its anterior surface being identified and isolated (Fig. 349). The **relations** are: *in front*, the pleuræ, the margins of the lungs, the remains of the thymus, the prolongation of the pretracheal fascia, the left phrenic, left vagus, left recurrent laryngeal and the superficial cardiac nerves and the left superior intercostal vein; *above*, the left innominate vein, the beginning of the innominate, left common carotid and left subclavian arteries; *below*, the bifurcation of the pulmonary artery, the ligamentum arteriosum, the left bronchus, the left recurrent laryngeal nerve and the superficial cardiac plexus; *behind*, the deep cardiac plexus, the left recurrent laryngeal nerve, the bifurcation of the trachea, the œsophagus and the thoracic duct.

The left phrenic nerve has been traced (p. 721).

The **left vagus** should be picked up where it crosses the left end of the arch and followed downward to the posterior aspect of the root of the lung (p. 744); it should be followed upward behind the left innominate vein to the root of the neck. Its recurrent laryngeal branch (p. 380) should be traced around the vessel to its posterior aspect and then upward to the side of the trachea (Fig. 349).

The **superficial cardiac plexus,** found in the concavity of the arch, should be recognized and the two nerves that form it, the left superior cardiac branch of the sympathetic and the left inferior cervical cardiac of the vagus, should be followed upward over the aortic arch and the left common carotid artery to the root of the neck (Fig. 349).

The **ligamentum arteriosum** should be examined; it is the fibrous remnant of the fetal ductus arteriosus (ductus Botalli) through which the blood of the fetal pulmonary artery is conveyed to the aorta.

The **branches** of the transverse portion of the arch are the *innominate*, the *left common carotid* and the *left subclavian*.

The Innominate Artery (a. anonyma) (Fig. 348).—The innominate or brachio-cephalic artery, an inch and a half to two inches long should

be traced from its **origin** to its **termination** behind the right sterno-clavicular joint where it divides into the right subclavian and the right common carotid. It is, *in front*, **related** to the left innominate and right inferior thyroid veins, the right inferior cervical cardiac branch of the vagus, the pretracheal fascia and the sternum; *on the right*, to the right innominate vein, the vagus and the pleura; *on the left*, the left inferior thyroid vein, the left common carotid and the trachea; *behind*, to the trachea and the pleura (*vide* p. 386). It sometimes gives off the *thyroidea ima* (p. 362).

The **left common carotid artery** (Fig. 352), **arising** from the highest part of the aortic arch, will be traced upward and outward to the left sterno-clavicular joint and will be noted to be **related** *in front* with the

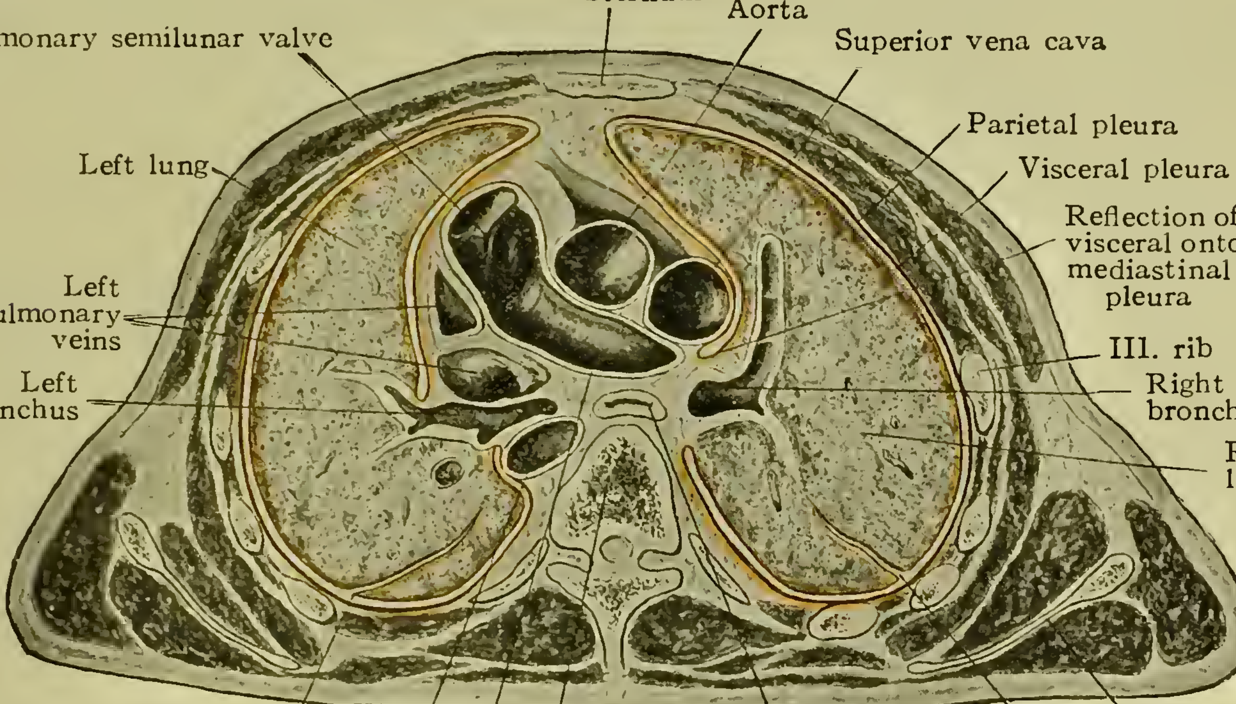

FIG. 351.—Transverse section of thorax at level of fifth thoracic vertebra.

left innominate vein, the pretracheal fascia and the sternum; *internally*, with the innominate artery and the inferior thyroid vein; *externally*, with the vagus, pleura, lung and left subclavian artery; *behind*, with the left recurrent laryngeal nerve, the trachea, œsophagus and the thoracic duct. For its course in the neck, see page 369.

The **left subclavian artery** (Fig. 352), arising from the left extremity of the aortic arch, should be followed upward to the inner border of the scalenus anticus; its further course is noted at page 383. It is **related** *in front* with the internal jugular, innominate and vertebral veins, the left common carotid artery, the phrenic, vagus and cardiac nerves; *externally*, with the pleura and lung; *internally*, with the trachea,

œsophagus and thoracic duct; *behind*, with the œsophagus, thoracic duct, inferior cervical ganglion and longus colli muscle.

The Pulmonary Artery or Pulmonary Aorta.—This vessel, contained within the pericardium (p. 723), **arises** from the left side of the base of the right ventricle (Fig. 350) in front of the origin of the aorta and between the right and left auricular appendages and the right and left coronary arteries. Removing the serous pericardium which encloses it and the ascending aorta, it should be slightly separated from the latter vessel, which lies on its right side.

Nerves passing from the superficial cardiac plexus to the front of the heart will be found on the vessel beneath the pericardium: these are joined by branches from the deep cardiac to form the right coronary plexus. The left coronary artery may be traced behind it. If elevated, its relation, behind, with the left auricle is seen. Its terminal **branches,** the **right** and **left pulmonary arteries,** already partly dissected, should be followed to the roots of the lungs, the right branch passing behind the ascending aorta, the left in front of the descending aorta.

The *pulmonary veins* will be more conveniently dissected at a later stage.

The Heart.—The *position* of the heart has been studied (p. 719). The epicardium or visceral pericardium and the fatty tissue should now be removed from the surface to expose the blood-vessels and nerves and the general form of the heart. The *right auricle*, forming the front part of the base of the heart, receives the superior vena cava at its upper posterior angle and the inferior vena cava at its lower posterior angle, while below, it is differentiated from the right ventricle by the auriculo-ventricular furrow (Fig. 352). On its right side and in front it presents the *auricular appendix*. The *right ventricle* constitutes the greater portion of the remainder of the anterior surface of the heart, the obliquely directed anterior interventricular furrow along its left border indicating the boundary between it and the left ventricle. The *left ventricle* appears to a limited extent anteriorly along the left margin of the heart. The *left auricle* is hidden in front by the aorta and pulmonary artery, its *auricular appendix* projecting forward to some extent to the left of the pulmonary artery.

The **right coronary artery** (Fig. 352) should be traced from its origin in the anterior sinus of Valsalva along the anterior auriculo-ventricular furrow to the right border of the heart, around which it curves to reach the posterior surface; its *transverse branch*, running along the groove between the left auricle and ventricle and its *descending branch*, passing downward along the posterior interventricular furrow, will be followed later. The *marginal branch* should be traced along the right border of the right ventricle. The *right coronary plexus*, derived from the superficial and deep cardiac plexuses, chiefly from the latter, takes the

same general course as the artery, after reaching it by coming forward between the aorta and the pulmonary artery (Fig. 349).

The **left coronary artery,** arising from the left posterior sinus of Valsalva (*vide infra*), comes forward between the pulmonary artery and the left appendix auriculæ and sends one of its terminal branches, *ramus descendens*, downward in the anterior interventricular furrow and the other, *ramus transversus*, around the left border of the heart

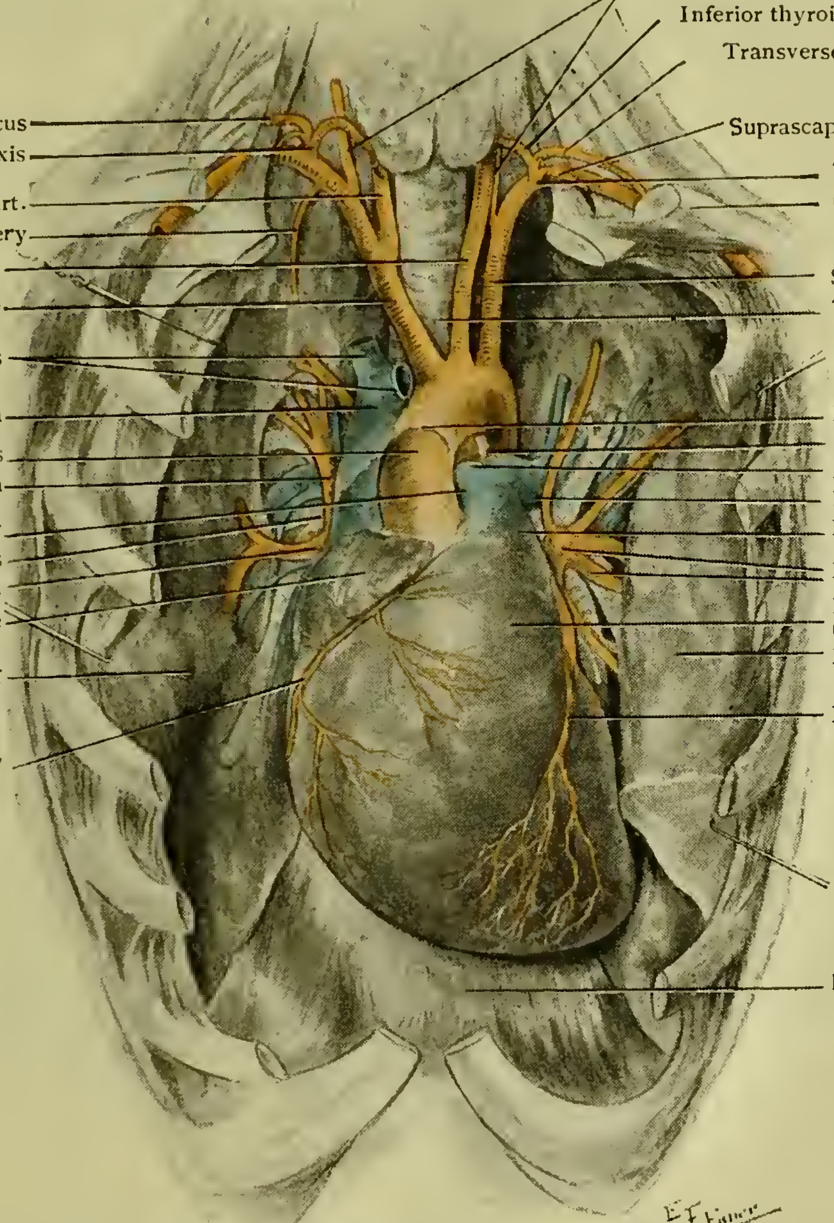

FIG. 352.—Dissection showing aortic arch and its branches; lungs have been pulled aside.

to anastomose with the ramus transversus of the right coronary. The *left coronary plexus*, derived from the deep cardiac plexus chiefly, follows the artery.

The **cardiac veins** do not correspond with the arteries. Certain cardiac veins on the front of the right ventricle open directly into the cavity of the right auricle. The **right marginal vein** may be followed upward along the right margin of the right ventricle to its termination in the **right coronary vein** (Fig. 350).

The **left coronary vein** (vena cordis magna) should be traced upward along the anterior interventricular groove to the auriculo-ventricular groove and along this groove to the left around the left margin of the heart to its termination in the coronary sinus (Fig. 353).

The **coronary sinus,** in the left part of the posterior auriculo-ventricular furrow, is to be exposed by drawing the apex of the heart upward and forward to bring into view its postero-inferior aspect. It terminates in the right auricle below the inferior caval orifice. Its **tributaries** are the *left* or *great coronary vein* near its left extremity; the

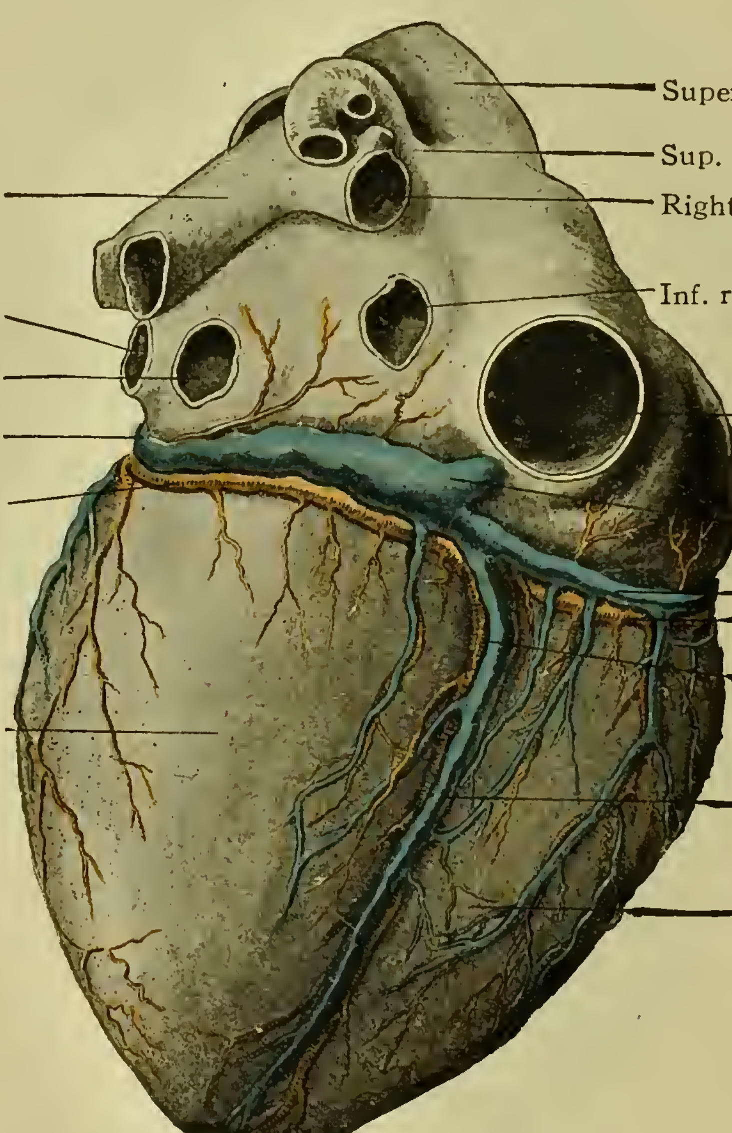

FIG. 353.—Postero-inferior surface of injected heart, viewed from below and behind.

right or *small coronary vein* which enters its right extremity after traversing the right portion of the posterior auriculo-ventricular sulcus; the *middle cardiac vein*, which ascends along the posterior interventricular furrow; the *posterior cardiac* or *left posterior ventricular vein*, which passes upward over the middle of the posterior surface of the left ventricle; and the *oblique vein of the left auricle*. The coronary sinus should be slit open to expose the valve at the orifice of the left coronary vein that differentiates the sinus from the latter (Fig. 353).

The **oblique vein of the left auricle** (Marshall), descending obliquely across the posterior surface of the left auricle to open into the coronary sinus, is connected by its upper end with the fibrous band enclosed in the vestigial fold of Marshall (p. 724) the vein and the band representing the aborted portion of the left superior cava while the coronary sinus represents the fetal duct of Cuvier of the left side (Fig. 353).

The Right Auricle (*Atrium Dextrum*).—Drawing the heart toward the left, the auricle should be cut vertically along its right side, a second incision being made from the middle of the first to the tip of the appendix.

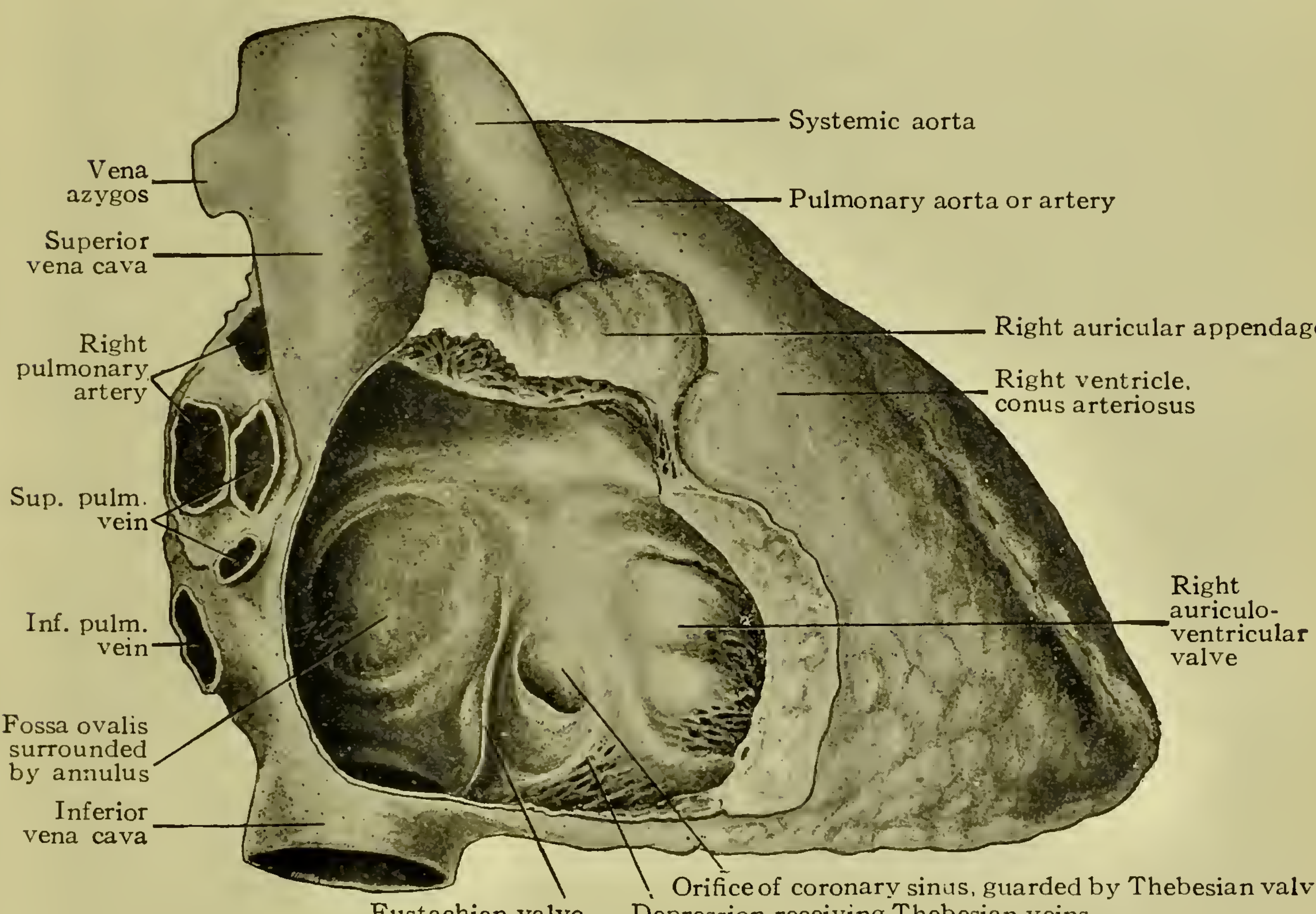

FIG. 354.—Interior of right auricle exposed after removal of part of heart wall.

Note the thinness of the walls, the lining of serous membrane, the *endocardium*, and the comparative smoothness of the inner surface except in the appendix, where are seen the **musculi pectinati** as a network of ridges. The **superior** and **inferior caval orifices**, through which the venous blood of the systemic circulation enters the heart, will be noted at the upper and lower posterior angles respectively; at the inferior caval orifice note the crescentic **Eustachian valve.** The **orifice of the coronary sinus,** guarded by the **Thebesian or coronary valve,** is seen below the inferior caval orifice. The small depressions or apertures are the orifices of the *venæ Thebesii* and of some of the cardiac veins. On

the posterior wall, between the caval orifices, the small **tubercle of Lower** may sometimes be seen.

The **median** or **septal wall** presents a depression, the **fossa ovalis,** surrounded by an elevated fold, the **annulus ovalis,** marking the site of the fetal *foramen ovale* through which the venous blood that comes through the inferior cava passes from the right auricle to the left during prenatal life (Fig. 354).

The **right auriculo-ventricular orifice** is to be noted as a large aperture in the floor of the auricle for the passage of the blood into the right ventricle.

The Right Ventricle.—The **conus arteriosus** or **infundibulum** is to be noted as the left portion of the base of the ventricle from which the pulmonary artery arises. Make an incision from the summit of the conus to the apex of the right ventricle, parallel with and a half inch to the right of the interventricular furrow, and another from the upper end of the first cut parallel with and a half inch below the auriculo-ventricular groove, taking the precaution to pass a finger through the auriculo-ventricular orifice into the ventricle to guard the valve-leaflets from injury. Turn the flap downward, exposing the triangular ventricular cavity. Note the convexity of the postero-median or *septal wall,* due to the fact that the form of the thicker walled left ventricle dominates that of the right. Note the membranous character of the upper part of the septum (*pars membranacea septi*), the portion formed by the lower part of the fetal aortic septum (Fig 355).

The **right auriculo-ventricular** or **tricuspid orifice** at the right side of the base, should be examined, its leaflets being noted to coalesce to form a continuous ring near the base of attachment to the fibrous ring surrounding the orifice. Note the large *anterior* or *left* or *infundibular cusp,* the smaller *posterior* or *septal cusp* and the freely movable *right* or *marginal cusp,* as well as the attachment of the *chordæ tendineæ* to the free margins and ventricular surfaces of the leaflets. The valve-leaflets consist of a thin layer of fibrous tissue covered by endocardium.

The **larger anterior papillary muscle,** its chordæ passing to the right and left leaflets, and the smaller **posterior muscle,** often consisting of several parts, its chordæ going to the right and the posterior cusp, should be noted, as also the springing of some chordæ directly from the ventricle wall. The other **columnæ carneæ** are responsible for the honey-comb appearance of the wall of the ventricle, some of these fleshy columns being ridges attached throughout their length to the heart wall, others being attached only at each extremity, while the **papillary muscles** constitute the group that are attached to the wall by one end and at their free extremity give attachment to the chordæ tendineæ. The arrangement of the valve-cusps, the chordæ and the

muscles is such as to prevent the flapping of the cusps into the cavity of the auricle during the contraction of the ventricle. By closing the orifice when the ventricle contracts, they compel the blood to pass into the pulmonary artery.

The **pulmonary artery orifice** presents the **semilunar valve,** consisting of three leaflets. These may be exposed by cutting the artery longitudinally after having applied a ligature to its upper end. The semilunar form of the leaflets, the manner in which they come together to

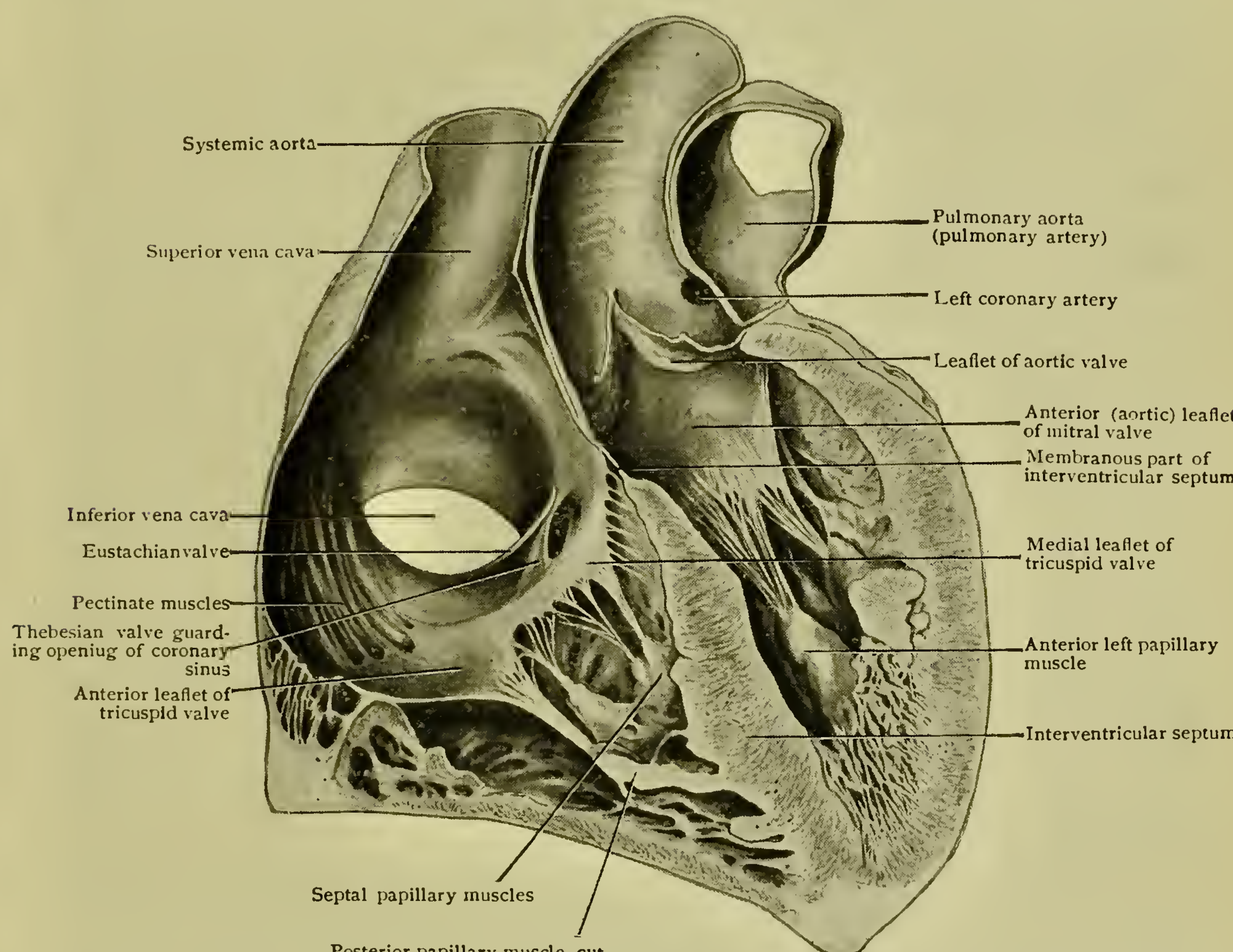

FIG. 355.—Posterior portion of heart, hardened *in situ* and sectioned parallel to posterior surface; viewed from before.

close the opening and the small nodule, *corpus Arantii*, on the middle of the free margin of each, are to be noted (Fig. 357).

The superior cava may now be slit open longitudinally (p. 724) and the inferior cava, already cut below the diaphragm, may be detached from the margins of the caval aperture of that muscle.

The Left Auricle (*Atrium Sinistrum*).—The external surface and general form of this chamber of the heart, only the auricular appendix of which is visible from the front, should be exposed by removing the pulmonary artery, after cutting it across just above its origin, and pulling

the ascending aorta to the right. Pulling the left side of the heart forward and to the right will expose the posterior surface of the auricle and the two pulmonary veins of each side terminating in it (Fig. 353).

The interior of the auricle should be exposed by making a crucial incision into its front wall or by removing a part of the wall; the inner surface of the wall is seen to be without musculi pectinati except in the auricular appendage. On the septal wall, the area, usually somewhat depressed, corresponding to the situation of the fossa ovalis should be determined by comparison with the septal wall of the right auricle. The **left auriculo-ventricular** or **mitral aperture** is seen in the lower part of the cavity.

The Left Ventricle.—The shape and relations of this chamber should be noted and the attachment of the aorta to its base made out. The interior of the vestibule should be dipslayed by removing or reflecting the left portion of the wall. This may be effected by an incision parallel with and a half inch to the left of the anterior interventricular furrow, beginning near the base of the ventricle by pushing the point of the knife directly through the wall into the cavity, then directing the point toward the apex of the heart and cutting the wall from within outward along the line indicated above. Pulling to the left the left edge of this cut to afford a view of the interior, so much of the posterior or inferior ventricular wall should be removed as may be done without destroying the **posterior papillary muscle.** The wall of this chamber is seen to be from two and one half to three times as thick as that of the right ventricle. The upper right portion of the cavity, the **aortic vestibule,** having fibrous instead of muscular walls, presents the *orifice of the aorta,* while to the left of this and on a posterior plane is the *auriculo-ventricular orifice.* The **columnæ carneæ** are smaller, more numerous and rather more intricate than those of the right ventricle, while the **musculi papillares** are much larger (Fig. 355).

The **aortic orifice** should first be inspected from below and then the aorta should be opened by a longitudinal incision through its front wall beginning a half inch above its origin. The three leaflets of the *aortic semilunar valve* are like those of the pulmonary valve (p. 733) except as to relative position, there being in this case one anterior and two postero-lateral leaflets corresponding with the similar disposition of the aortic **sinuses of Valsalva,** the three pouch-like dilations at the beginning of the aorta. The origin of the left coronary artery from the left posterior sinus should be noted (Fig. 355).

The left **auriculo-ventricular orifice** is seen to be smaller than the right and to be guarded by a valve of two leaflets, the **bicuspid** or **mitral valve.** The *anterior* or *aortic cusp,* attached to the part of the auriculo-ventricular fibrous ring connected with the aortic ring, comes therefore into relation with the aortic orifice; the posterior cusp is attached

to the posterior portion of the fibrous ring. The continuity of the two cusps near their attached borders and the occasional presence of additional smaller cusps are noteworthy. The **anterior papillary muscle,** springing from the anterior or septal wall, and the **posterior muscle,** attached to the posterior wall, give chordæ tendineæ in each case to each of the cusps.

Having studied the chambers of the heart, the apertures through which they communicate and the great vessels that spring from them, the dissector should consider the course of the blood through the heart. The venous blood from all parts of the body, reaching the right auricle through the superior and inferior venæ cavæ, passes thence through the right auriculo-ventricular orifice to the right ventricle, from which it is forced through the pulmonary orifice into the pulmonary artery and its right and left branches to the lungs for oxygenation. Returning from the lungs through the pulmonary veins to the left auricle, it reaches the left ventricle through the left auriculo-ventricular aperture and is forced by the contraction (systole) of the ventricle through the aortic valve into the aorta for conveyance to all parts of the body.

In the **fetal circulation,** a part of the blood of the right auricle—that coming through the inferior vena cava, which is partly arterial blood since a portion of it has been returned from the placenta through the umbilical vein—passes through the foramen ovale into the left auricle, the latter chamber not receiving blood from the lungs since they are not as yet functionating. From this point, the course of the bloodstream is identical with that of the adult condition. The remaining portion of the blood of the right auricle—that collected through the superior vena cava—pursues the usual course through the right ventricle and into the pulmonary artery. Since the lungs are not pervious, this venous blood passes from the pulmonary artery through the ductus arteriosus (p. 726) to the aorta, mingling there with the stream from the left ventricle.

The Relations of the Cardiac Valves to the Chest-Wall.—The **pulmonary orifice** is behind the upper part of the third left chondro-sternal junction, while the **aortic aperture** lies back of the lower part of the same joint, at a deeper plane and a little nearer the mid-line. The **right auriculo-ventricular aperture** is placed lowest and farthest to the right, being behind the sternum opposite the right fourth intercostal space, while the **left auriculo-ventricular orifice** is deeply placed behind the left margin of the sternum, on the level with the fourth left cartilage.

The Deep Cardiac Plexus.—The arch of the aorta, behind which the plexus lies, must be removed to expose it, when it will be found above the bifurcation of the pulmonary artery and in front of the bifurcation of the trachea. In removing the aortic arch, note the nerves that connect this plexus with the superficial cardiac plexus and take care to

avoid injury to the nerves that approach the plexus across the front of the trachea (Fig. 357). The plexus is formed by all the cardiac branches of the vagus, sympathetic and recurrent laryngeal nerves except the left superior cardiac branch of the sympathetic and the left inferior of the vagus, which form the superficial plexus. The nerves of the right and left sides join respectively the right and left portions of the plexus.

The **branches,** from the **right portion,** the *right* or *anterior coronary* and the *right anterior pulmonary plexuses* and from the **left portion,**

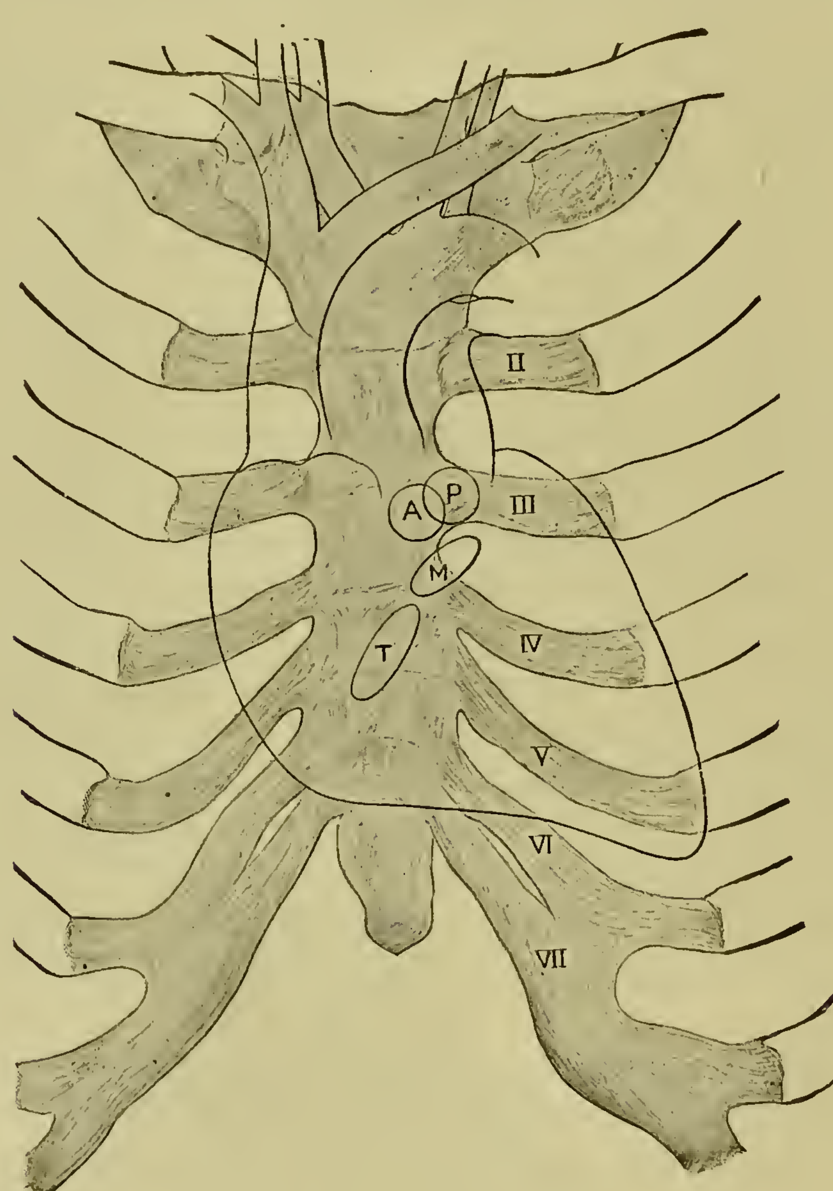

Fig. 356.—Position of heart and valves in relation to anterior thoracic wall. A, aortic valve; P, valve of pulmonary aorta; T, tricuspid valve; M, mitral valve.

the *left* or *posterior coronary* and the *left anterior pulmonary plexuses,* have been encountered (pp. 728 and 729).

The **fibrous rings** (annuli fibrosi) at the bases of the ventricles are now to be examined, the heart being removed from the body after severing its vessels. The auricles may be cut away from the ventricles with scissors, when the rings, one for each auriculo-ventricular orifice and one each for the pulmonary and aortic orifices, should be exposed, the

attachment to them of the muscle-fibres and of the valve-leaflets being noted. The ring of the pulmonary artery aperture is separated from the others. Note the fibrous masses respectively between the right auriculo-ventricular and aortic rings and between the latter and the left auriculo-ventricular ring.

The **muscular substance** of the heart is best studied in a sheep's or bullock's heart that has been boiled for a short time. While some of the superficial muscular fibres of the auricles are common to the two

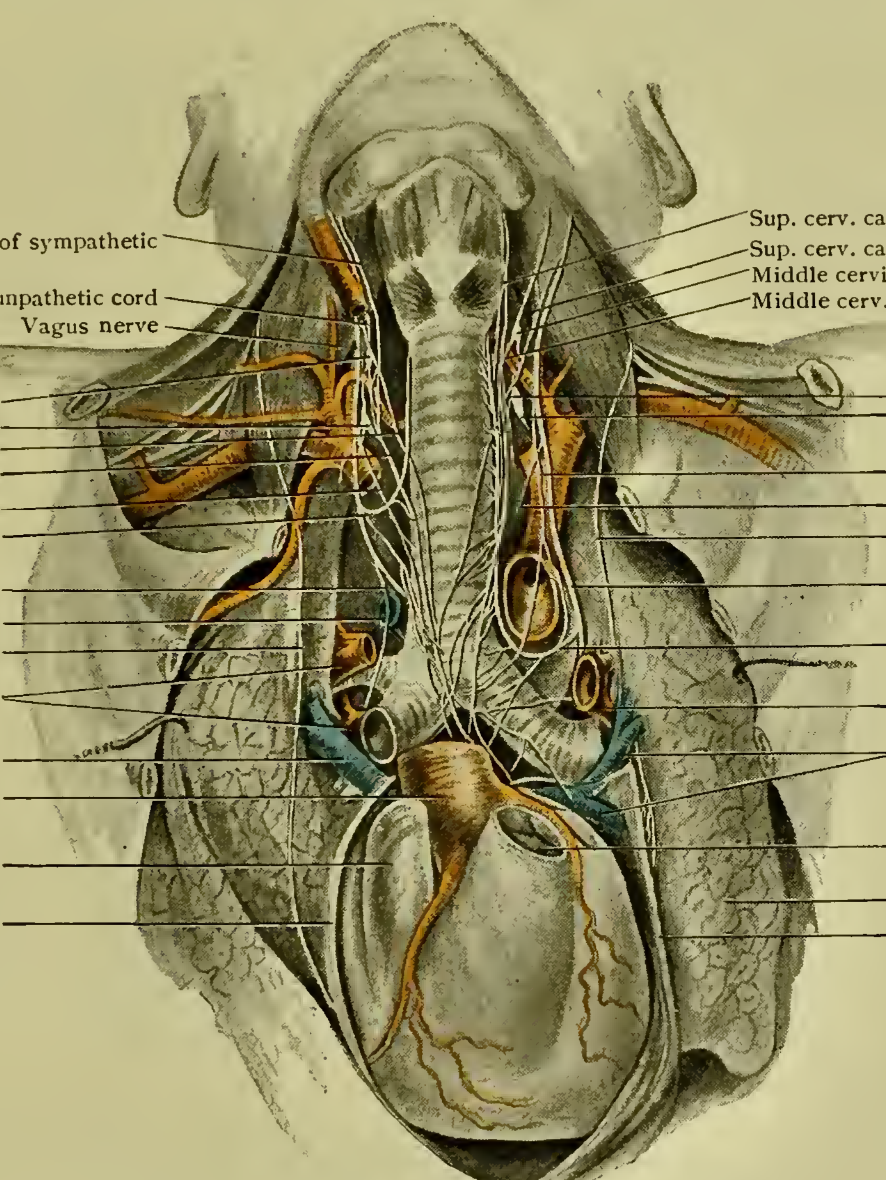

FIG. 357.—Dissection showing cardiac branches of pneumogastric nerves and of sympathetic cords; aortic arch and branches and pulmonary artery partially removed; pericardium laid open.

chambers, it may be stated that the fibrous rings constitute the points of attachment for both the auricular and the ventricular fibre-bundles, and that the latter are extremely complicated. Further, the auricular fibres are entirely distinct from the ventricular fibres except for the connection by the **auriculo-ventricular fasciculus** or **muscular bundle of His.** This connects the auricular septum with the ventricular septum and may be exposed by detaching the posterior or septal leaflet of the tricuspid valve, removing the anterior half of the auriculo-ven-

tricular ring and dissecting the endocardium from the lower part of the posterior wall of the right auricle near the auricular septum and from the upper part of the interventricular septum. The bundle, relatively pale in color, will be found to divide, at the lower part of the pars membranacea septi, into two portions which respectively come into relationship with the right and left aspects of the interventricular septum. The bundle of His is regarded as being the pathway of the contraction wave from the auricles to the ventricles and as being related, therefore, to heart-block.

The Trachea.—The trachea begins at the level of the sixth cervical vertebra; its cervical portion is considered at page 363. Since it terminates—by dividing into the two bronchi—opposite the fourth thoracic vertebra, it passes through the superior mediastinum (p. 721). Its length is four and one half to five inches. The structures **related** to its *anterior surface*—the deep cardiac plexus, the transverse part of the aortic arch, the left innominate vein, the innominate and left common carotid arteries—have been demonstrated. Note its *lateral relations* with the lungs and pleuræ and, on the left side, also with the left recurrent laryngeal nerve, the left part of the aortic arch, and the left subclavian artery. Pull it somewhat to one side and note the œsophagus and thoracic duct *behind* it. Note that the trachea is not a collapsed tube, its patency being maintained by the sixteen to twenty rings of fibro-elastic cartilage enclosed within the outer membranous lamina of its wall. The rings may be felt by the finger passed along its surface. Compression of the tube between the thumb and finger will show its calibre to be capable of some degree of variation owing to the incompleteness of the rings behind. In the narrow interval between the ends of the rings along the dorsal wall of the trachea, is the **trachealis muscle,** consisting of transversely arranged fibres, which, by reason of their situation and their connection with the rings, are able to diminish the calibre of the tube.

The **interior** of the trachea may be exposed, after completing the examination of the lungs, by cutting along the dorsal wall with scissors, laying open the entire tube. The septum or crest (carina tracheæ) between the openings of the bronchi is seen to be (usually) to the left of the mid-line of the tube; foreign bodies dropping through the trachea therefore—and also because of the larger calibre of the right bronchus—more often fall into the right bronchus than into the left. The yellowish circular ridges on the inner face of the tube are the partly masked tracheal rings.

The Lungs (Pulmones).—An attempt should be made to inflate the lungs by forcing air into the upper part of the trachea with a bellows or air-pump. If successful, the shape of the lungs and the greater length but less width of the left lung as compared with the right will

be apparent. A better method of preserving the form of the lungs is to force starch-mass into the cervical part of the trachea. The setting of the mass in the smaller air-tubes confines the air which has been forced forward by the mass, while the latter, being without coloring matter, serves to differentiate the air-tubes from the vessels.

The general relations of the lungs to the pericardium and the disposition of the parietal and visceral portions of the pleural membrane (pp. 718 and 719), as seen in cross section, are shown in Fig. 351.

The **visceral layer** of the pleura and the **pleural cavity** of each side are to be exposed by removing the costal portion of the parietal layer. The smooth polished character of the opposed surfaces of the two layers being noted, the hand should be passed into the pleural sac,

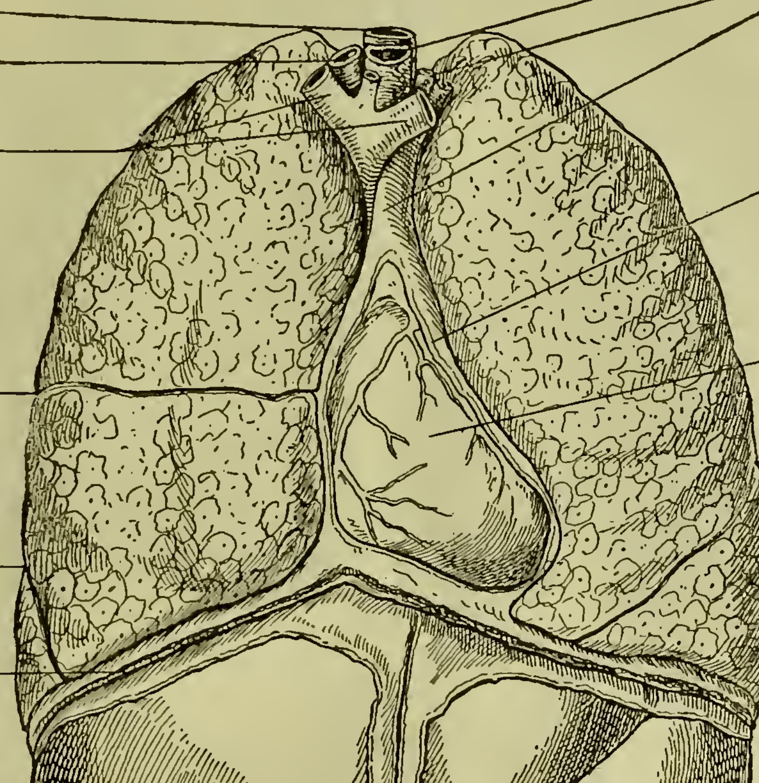

FIG. 358.—Anterior view of lungs and heart. (From photograph of His model.)

first forward and then backward until the root of the lung is reached in each case. The **ligamentum latum pulmonis** of each side should be identified as a double fold of the pleura formed by the downward continuation of the layers on the front and rear surfaces respectively of the root of the lung, these layers being continued medialward to the pericardium but presenting a free lower border.

The removal of at least a part of the visceral pleura must now be effected. The surface of lung exposed presents a characteristic mottling and many fine lines enclosing irregularly polygonal areas, the lines indicating the *connective tissue septa* that separate the *lobules* of the lung.

The **convex surface of the lung** is limited behind by the rounded posterior border which passes from the apex to the base parallel with

the spine, in front by the sharp anterior border and below by the lower border. The *anterior border* passes from the apex, which projects through the superior aperture of the thorax to a height of an inch or slightly more above the level of the first costal cartilage (p. 386), downward and inward to the middle of the upper end of the gladiolus, thence downward and slightly outward behind the sternum to the level of the sixth costal cartilage in the case of the *right lung*, from which point it slopes downward and outward along this cartilage to become continuous with the lower border; the anterior border of the *left lung* diverges outward

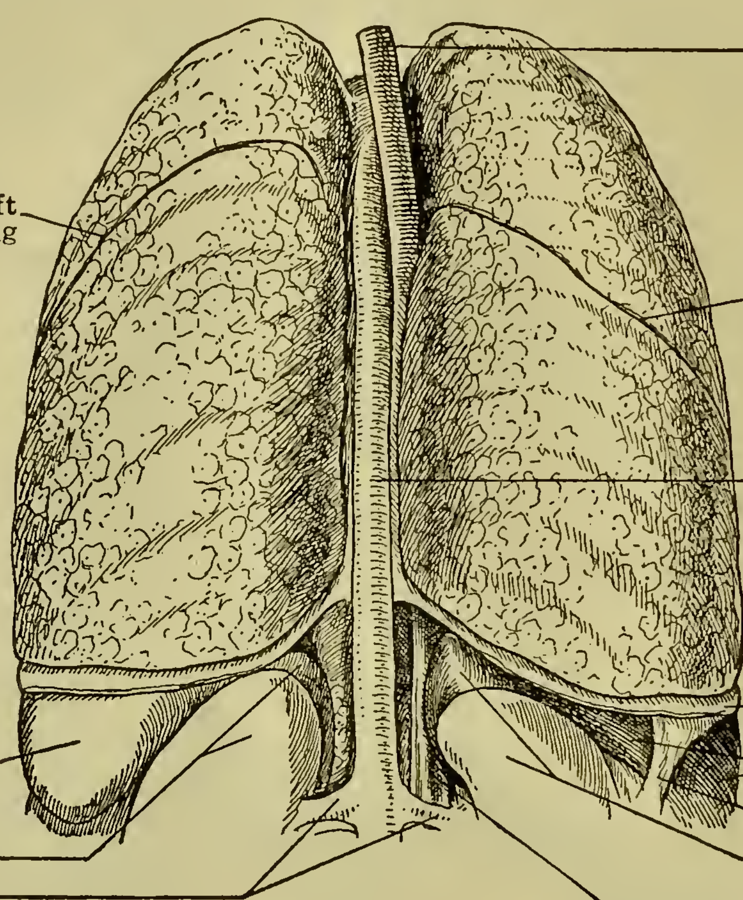

FIG. 359.—Posterior view of lungs (From photograph of His model.)

from the sternum opposite the fourth costal cartilage and passes downward behind the costo-chondral articulations to the seventh cartilage.

The **lower limit** of the *right lung* is at or slightly above the level of the tenth thoracic spine or eleventh rib behind, the eighth rib in the mid-axillary line, and the sixth rib in front in the mid-clavicular line; that of the *left lung* reaches to the eleventh rib behind, the ninth in the mid-axillary line and the sixth in front.

The **primary fissure** of the *right lung*, at the posterior border, is three inches below the apex, opposite the fourth thoracic vertebra, and passes across the convex surface to end near the junction of the sixth costal cartilage with its rib; that of the *left lung* is a little higher, beginning at the level of the third vertebra behind and ending at the sixth cartilage in front. Note the depth of the fissure and the continuation of the visceral pleura into it.

The **secondary fissure,** found only in the right lung, starts where the primary fissure crosses the mid-axillary line and passes horizontally forward to the anterior border of the lung at the end of the fourth costal cartilage. Thus the right lung presents three lobes, the left but two. Note that the upper lobes practically include, with the middle lobe in the case of the right lung, all of the anterior aspects of the lungs, while the lower lobes comprise about three fourths of the posterior portions of the convex surface.

The concave **mesial surfaces** can be properly studied only in the hardened specimen or in lungs inflated as directed on page 738. The deeper concavity of the left (Fig. 360) should be noted as well as the projecting *subcardiac shelf* and the *lingula* at the lower part of this

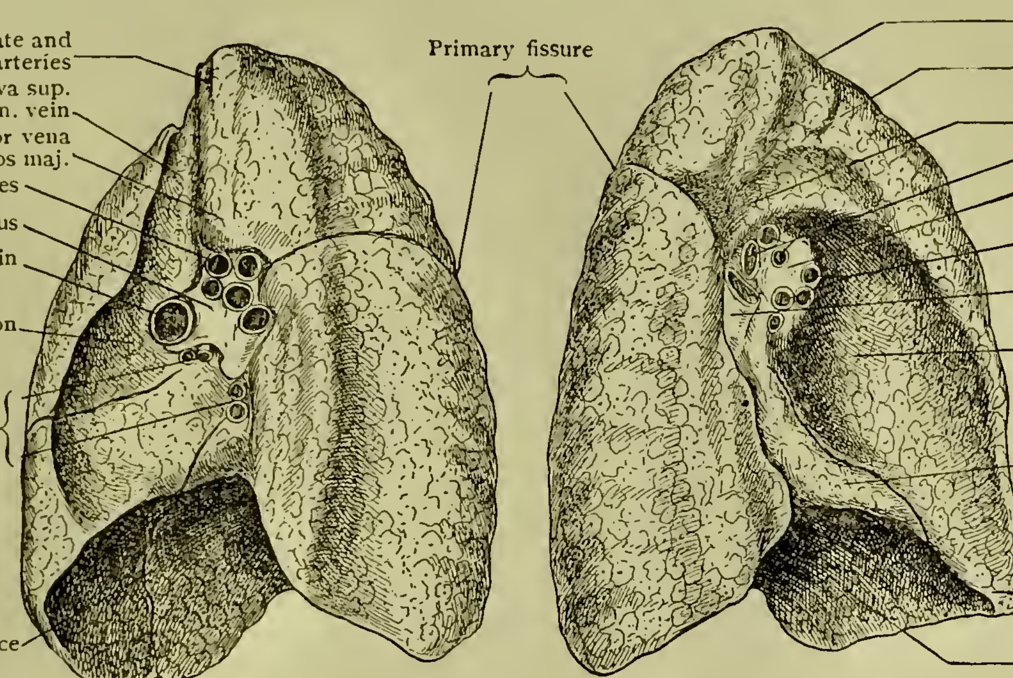

Fig. 360.—Mesial surfaces of lungs. The secondary bronchus of the right lung is seen beside the highest pulmonary artery. (His model.)

surface, the situation of the *hilum* for the entrance and exit of the structures forming the root of the lung and the various *impressions* or *grooves* for certain vessels (Figs. 358 and 360).

The concavity of the **inferior surface** or **base** of the lung may be appreciated by passing the hand beneath it.

The lungs should now be removed from the thorax, the bronchi being cut three fourths of an inch from the trachea. The structures forming the **roots** (p. 721) and their relations may now be examined more particularly. The *bronchus* in each case should be followed into the lung, its bipenniform manner of branching and the relation of its branches to the branches of the *pulmonary vessels* noted. The *nerve-fibres*, from the anterior and posterior pulmonary plexuses, which receive contributions from the vagi, the thoracic sympathetic ganglia and the superficial and deep cardiac plexuses, should be traced as far as may be possible.

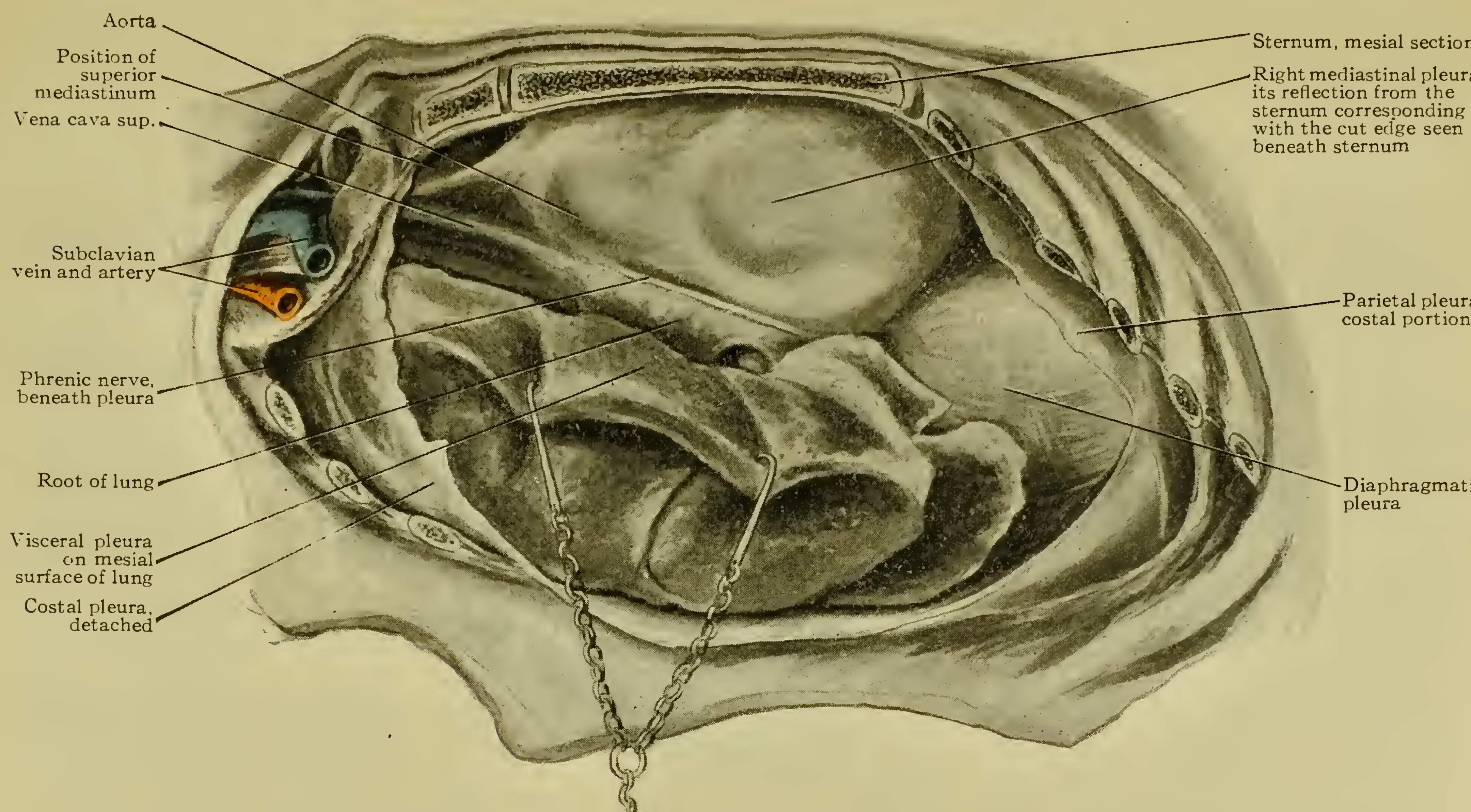

FIG. 361.—Right pleural chamber seen from the right. The right costal cartilages were first divided, the parietal pleura was separated from the ribs and the latter were divided and removed; the sternum was then sawn mesially. The lungs were previously distended by injection of starch-mass into the cervical portion of the trachea.

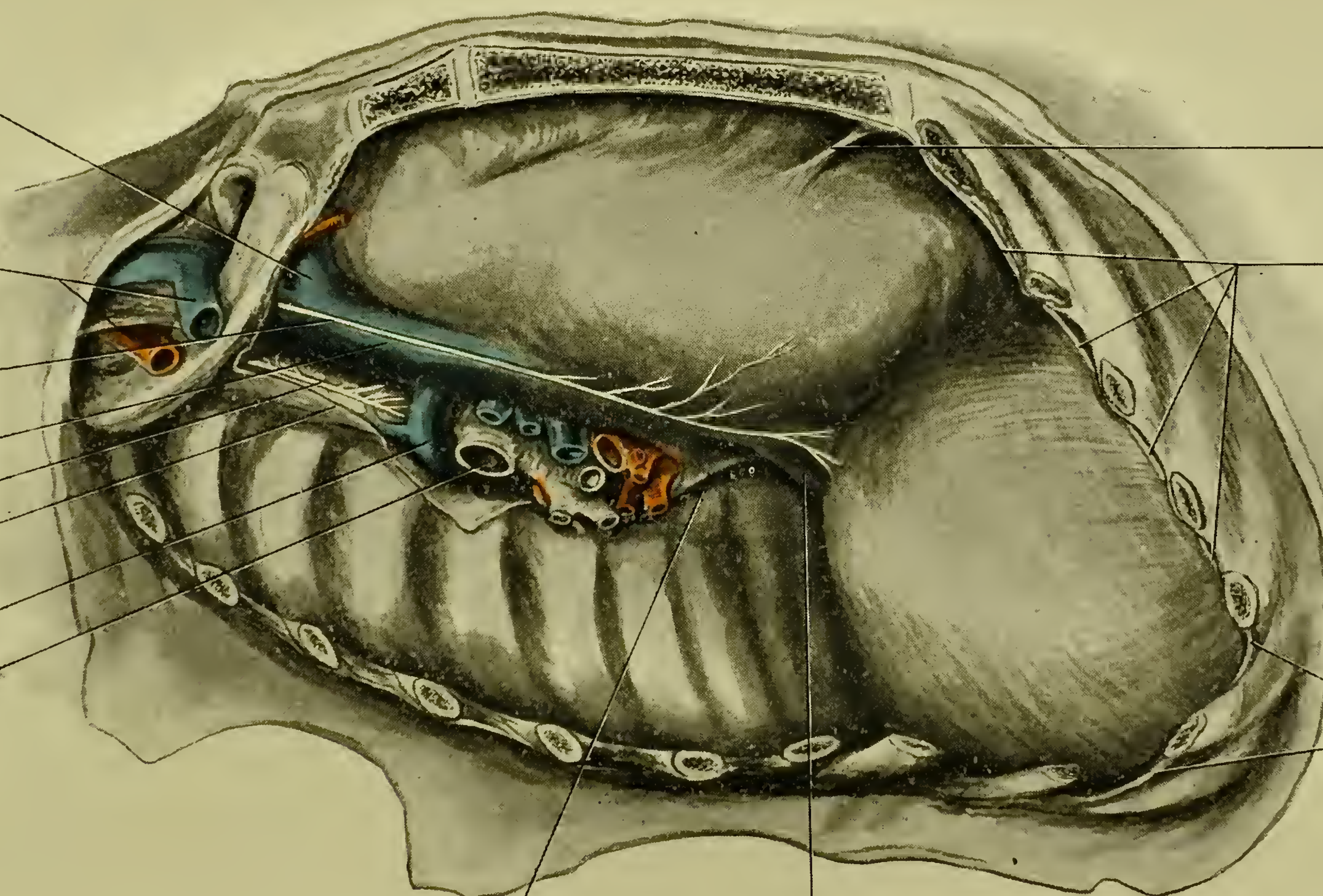

FIG. 362.—Right side of mediastinal spaces exposed by removal of right lung and mediastinal pleura. The pulmonary veins (red) and pulmonary arteries (blue) are shown in relation to bronchus.

The Œsophagus.—The **cervical portion** of the œsophagus is considered at page 458. The **thoracic portion** is to be noted as descending through the superior and posterior mediastini in front of the vertebral column, at first a little to the left of the mid-line and farther down, to the left and in less close association with the spine as it pierces the diaphragm (diaphragmatic portion) to terminate opposite the tenth thoracic vertebra or the disk below it, at the cardiac orifice of the stomach (abdominal portion). Its total *length* is about ten inches.

Relations.—Note first the relation to the aorta, behind the left end of whose arch it passes to lie for a short distance upon the right side of the vessel and then in front and later, when near the diaphragm, upon its left side. The thoracic duct, near the diaphragm, is to the right, at a higher level is behind it and at the fourth thoracic vertebra passes to the left. *In front*, from above downward, note the trachea, the left common carotid and left subclavian arteries, the left bronchus and aortic arch, and the pericardium; *on the right side*, the pleura, the vena azygos major, and, below, the thoracic duct and descending aorta; *on the left*, the left pleura and, above, the thoracic duct and descending aorta; *behind*, the vertebral column, longi colli muscles, right aortic intercostal arteries, vena azygos minor, descending aorta and thoracic duct (at the fourth vertebra). Now follow the pneumogastric nerves (p. 380), the left to the anterior and the right to the posterior surface and note their forming respectively the *anterior* and *posterior œsophageal plexuses* and the reassembling of their fibres to constitute again the two nerve-trunks. Note, if present, the *muscular bundles* passing to the left bronchus and also muscular slips to the right bronchus and to the pleura and pericardium.

The **pneumogastric nerves** (p. 656), traced as indicated above, should be noted as giving off **thoracic branches,** the *thoracic cardiac*, from the trunk of the right nerve but from the recurrent laryngeal of the left nerve, which go to the deep cardiac plexus; the *ventral* and *dorsal pulmonary branches* to assist in forming the anterior and posterior pulmonary plexuses already encountered (p. 741); and the *œsophageal branches* to form the œsophageal plexuses.

The Descending Thoracic Aorta.—The œsophagus should now be removed, the vena azygos major (p. 673) traced from the diaphragm to its termination in the vena cava superior (p. 748) and the thoracic duct (p. 674) followed from the diaphragm upward on the right side of the aorta and œsophagus and then behind them to its termination (p. 748).

The descending aorta is now seen *to begin* at the left side of the fourth thoracic vertebra and to gradually reach the mid-line in front of the last thoracic vertebra where it traverses the aortic opening of the diaphragm to become the abdominal aorta.

Relations.—*In front*, from above downward, the root of the left lung, the pericardium, the œsophagus and the diaphragm; *on the left*, the pleura and lung and, below, the œsophagus; *on the right*, the œsophagus above, and the vena azygos major and thoracic duct; *behind*, the vertebral column and the superior and inferior azygos minor veins. The nerve-fibres found upon the aorta are visceral branches of the thoracic sympathetic ganglia.

Branches.—The **right** and **left bronchial arteries** should be sought at their origin from the front of the aorta, the two vessels arising separately or by a common trunk, or the right bronchial arising from the first aortic intercostal artery. Their entrance into the lungs cannot be traced, since the roots of the lungs have been removed, but each artery may be followed to the posterior aspect of the corresponding bronchus (Fig. 362). They convey blood for the nutrition of the lungs. The **four** or **five œsophageal branches** arise from the front of the aorta and form an anastomotic chain along the œsophagus. The small **pericardiac branches** pass to the pericardium. The **posterior mediastinal branches,** of small size, are distributed to the lymph-nodes and areolar tissue of the posterior mediastinum and, the lower ones, to the diaphragm.

The **intercostal branches** (Fig. 363), nine in number, one for each intercostal space below the second, and the **subcostal,** which passes along the lower border of the last rib, should now be dissected. They arise from the back of the aorta and ascend to the intercostal spaces, the right vessels crossing the spinal column behind the pleura, œsophagus, thoracic duct and sympathetic nerve. Note the association of each artery with an *intercostal vein*, which lies above it and an *intercostal nerve*, which lies below, as it reaches the intercostal space, and its giving off here a *dorsal branch*. Note also that it rests against the front surface of the external intercostal muscle, being covered in front by fascia and parietal pleura, and that it then passes between the internal and the external intercostal muscle. Its further course and *branches* have been dissected (p. 716). The **dorsal branch,** as seen previously, gives off a *spinal branch* to the spinal cord and its membranes (p. 591), and *muscular* and *internal* and *external branches* after reaching the back.

The **intercostal arteries** of the *first* and *second spaces* are derived from the superior intercostal of the subclavian (p. 385).

The **thoracic aorta**—particularly its *arch*—is notably liable to disease (atheroma, calcification) leading to **aneurism.** The signs and symptoms of thoracic aneurism are determined by the part of the vessel affected; thus, in aneurism of the *proximal part of the ascending limb of the arch*, rupture is apt to occur into the pericardium (p. 724), while if the *upper part of the ascending limb* be implicated, bulging of the anterior thoracic wall is a conspicuous feature. In aneurism of the *transverse part of the arch*, laryngeal symptoms (cough, aphonia, dyspnœa) from pressure on the left recurrent

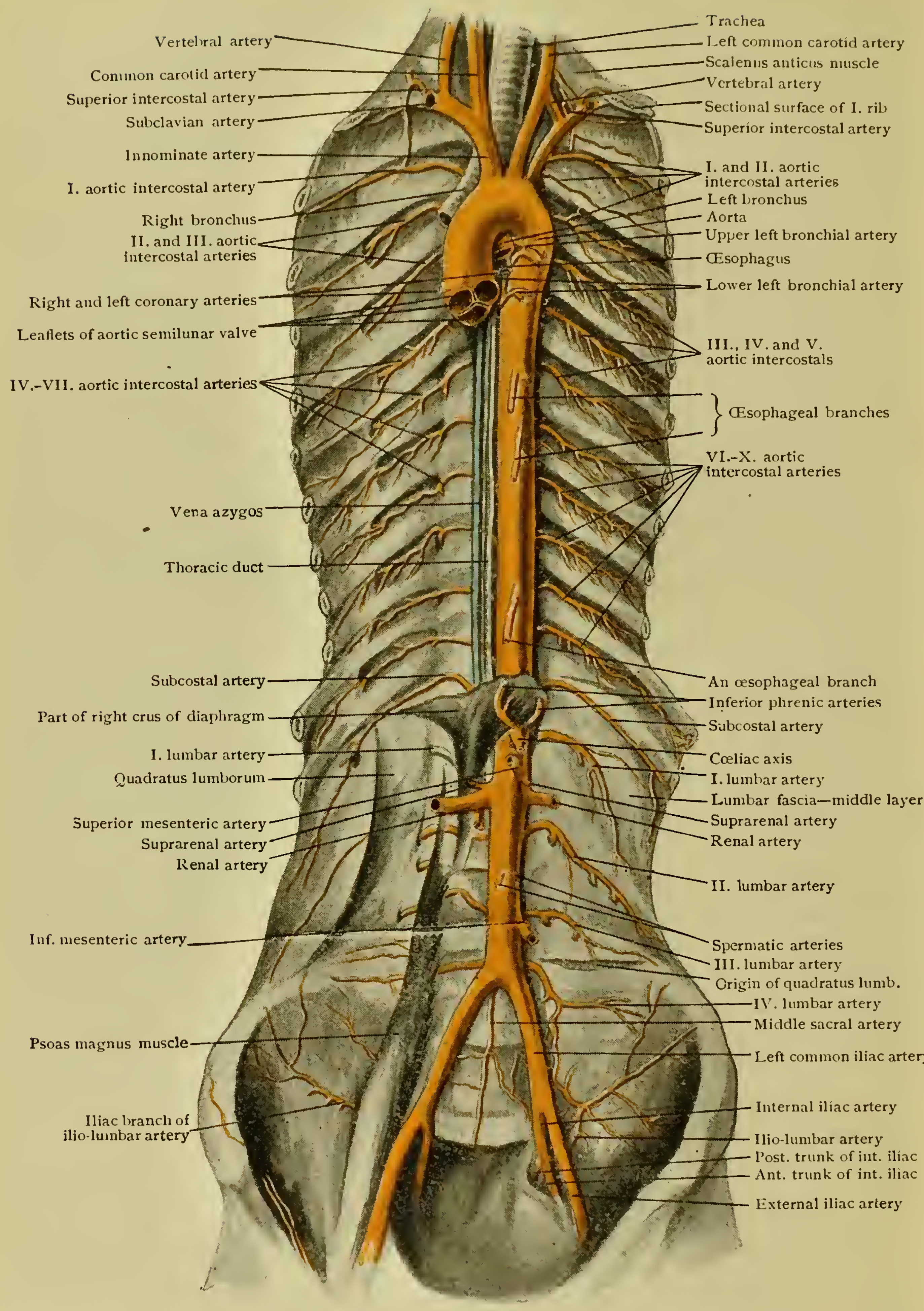

FIG. 363.—Aorta and its branches; ten intercostal arteries are present, first supplying second space; on right side internal intercostal muscles are in position, on left they have been removed.

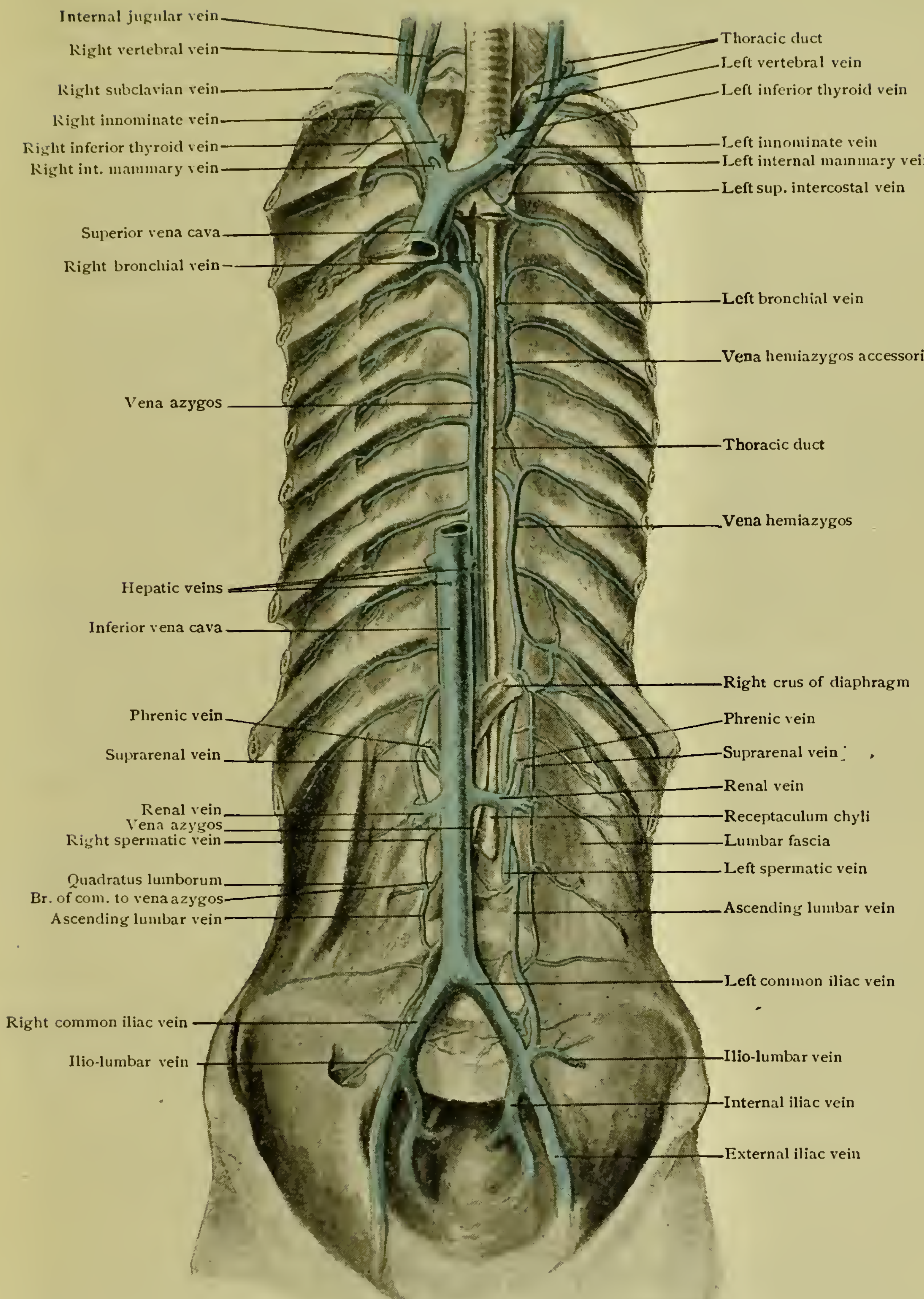

FIG. 364.—Portion of posterior body-wall, showing azygos veins, superior and inferior vena cava, and their tributaries.

laryngeal nerve are prominent. When the *descending part of the vessel* is affected, the vertebræ may be eroded with consequent curvature of the spine and symptoms referable to pressure upon the spinal cord and the intercostal nerves as well as upon the thoracic duct (interference with nutrition).

The Intercostal Veins.—The vein of the first space should be followed to its termination in the corresponding vertebral or innominate vein. The veins of the second, third and fourth spaces unite to form the *superior intercostal vein.* The **right superior intercostal vein** opens into the vena azygos major; the **left** usually receives the *left bronchial* and the *left superior phrenic veins* and was seen to cross the aortic arch to reach the left innominate vein. The veins of the remaining right intercostal spaces open directly into the **vena azygos major,** which thus drains all the spaces of the right side and also the lower spaces of the left side, since the left lower azygos vein opens into it. The veins of the left fourth, fifth, sixth and seventh spaces usually unite to form the **left upper azygos vein;** when this is absent, they drain into the left superior intercostal. The veins of the left spaces below the seventh open into the **left lower azygos vein** (p. 673).

Vena Azygos Major (Vena Azygos). — The abdominal portion of this vein has been dissected (p. 673). Traced upward from the aortic opening of the diaphragm (Fig. 364), along the right side of the aorta and thoracic duct and in front of the right intercostal arteries, it will be seen to arch forward over the right bronchus opposite the fourth thoracic vertebra to *terminate* in the superior vena cava (Fig. 362). Its tributaries are the *right lower ten intercostal veins*, the *right superior intercostal vein*, the *right bronchial vein* and the *hemiazygos vein.*

The Thoracic Duct.—The **origin** of the thoracic duct has been noted (p. 674). Passing from the aortic opening of the diaphragm upward along the vertebral column between the aorta and the greater azygos vein to the fourth thoracic vertebra (Fig. 364), it here inclines to the left of the œsophagus and ascends behind the arch of the aorta and the beginning of the left subclavian artery to the upper aperture of the thorax. Reaching thus the root of the neck, it arches over the subclavian artery and the scalenus anticus muscle to **terminate** in the left subclavian vein at its junction with the internal jugular vein. The duct is often difficult to demonstrate, appearing usually as a mass of yellowish tissue, the guide to which is its position as indicated above. In some cases it will be possible to inject it through a blunt hypodermatic needle.

The thoracic duct receives the lymph-vessels of the entire body except those of the right side of the head, face, neck, right upper limb, right side of thorax (including the right lung and the right side of the heart) and a part of the convex surface of the liver; these regions are drained by the **right lymph-duct,** which terminates in the right subclavian vein (Fig. 366).

The Thoracic Sympathetic Ganglia (Fig. 365).—These ganglia, usually twelve in number, are to be found beside the spinal column in front of the heads of the ribs, covered by the costal pleura. Beginning above, the ganglia and the association cords are to be successively

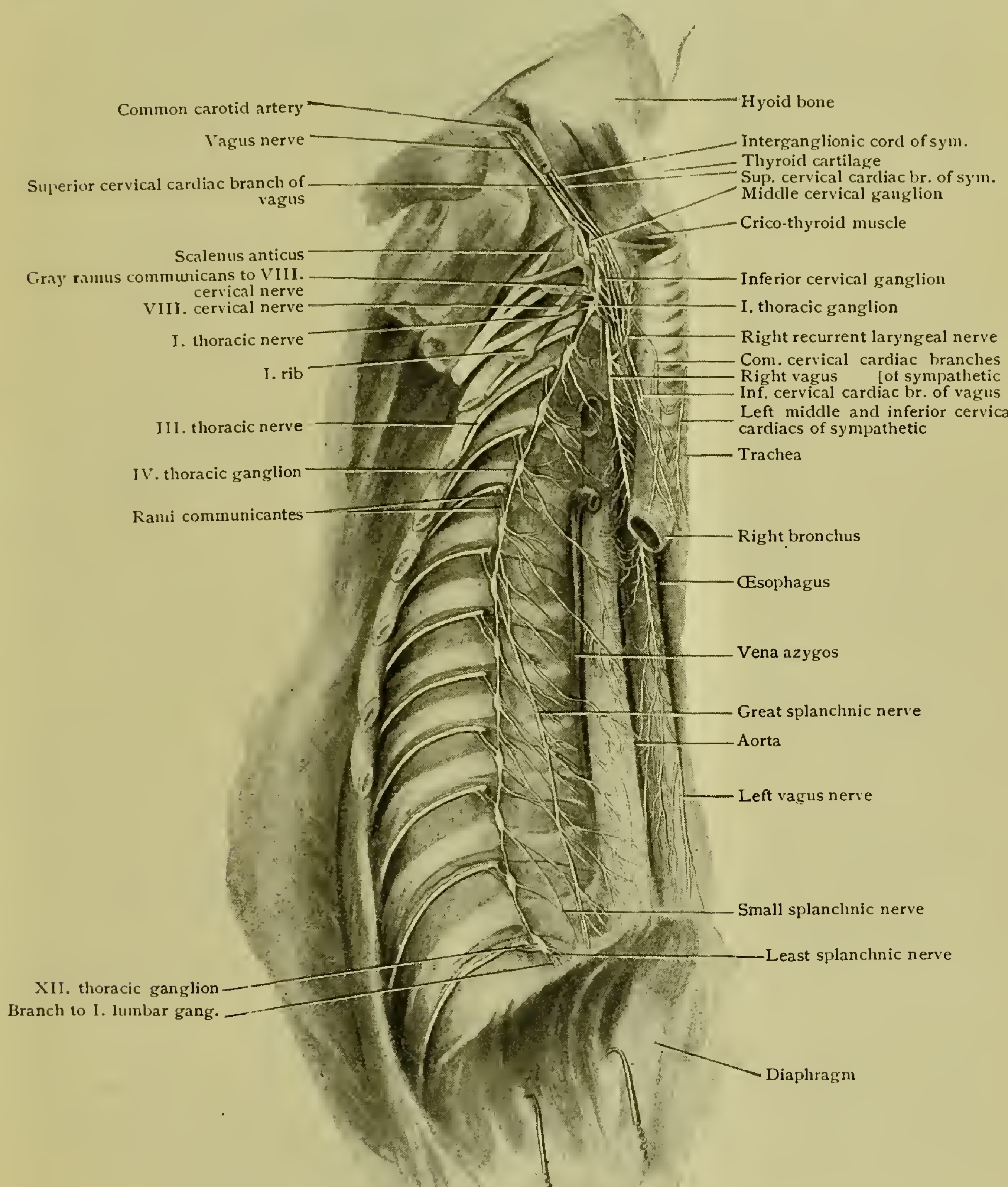

Fig. 365.—Dissection showing right gangliated cord of sympathetic and its branches.

denuded, the tissues being moistened with water or with weak alcohol to facilitate the work. The *white* and *gray rami communicantes* should be traced to the corresponding spinal nerves (Fig. 365). The **white rami** include the *splanchnic efferent* and the *splanchnic afferent fibres.*

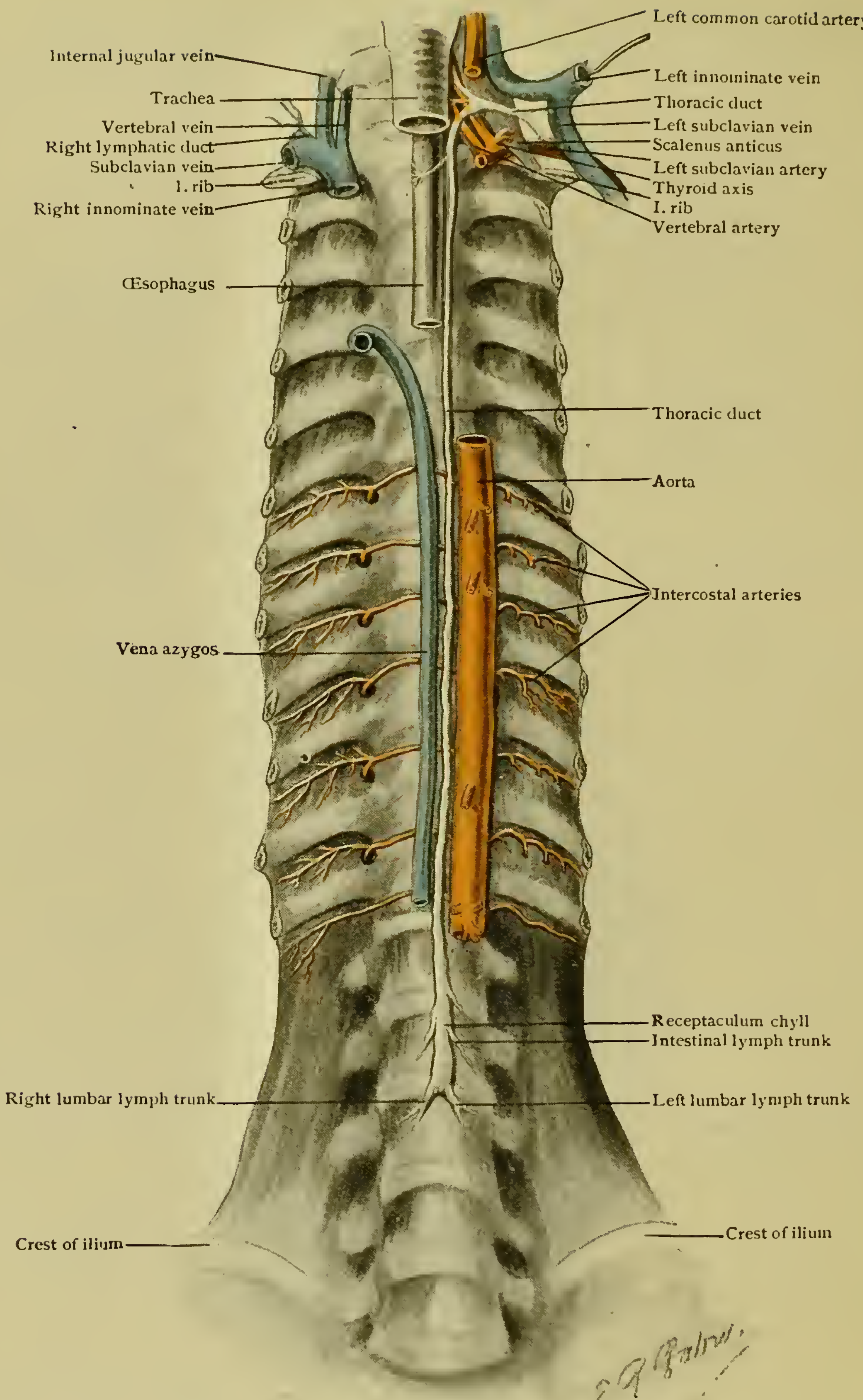

FIG. 366.—Dissection of posterior body-wall, seen from in front, showing thoracic duct and right lymphatic duct; veins have been laterally displaced to expose terminations of thoracic duct.

The **splanchnic efferent fibres,** axones of the cells of the lateral gray horns of the spinal cord, reach the ganglia by way of the spinal nerves and the white rami, those fibres that join the upper five ganglia turning upward to become a part of the cervical sympathetic, those that reach the lower seven ganglia either terminating in them or passing from them as constituents of their visceral branches (*vide infra*). The **splanchnic afferent fibres,** the sensory nerves of the thoracic and abdominal viscera, leaving the ganglia through their visceral branches, pass by way of the white rami, the spinal nerves and their dorsal roots to the spinal cord. The **gray rami** consist of sympathetic fibres which pass from the ganglia to the spinal nerves to be distributed as the vaso-motor and secretory fibres of the regions supplied by those nerves.

The **visceral branches** include the *pulmonary*, from the second, third and fourth ganglia to the posterior pulmonary plexus; the *aortic*, from the upper four or five ganglia, to form the plexus of the thoracic aorta; and the *splanchnic nerves*.

The **great splanchnic nerve** should be recognized as being formed by the assembling of the internal branches of the fifth to the ninth ganglia inclusive and should be followed to the diaphragm, whose crus it usually pierces to reach the abdomen where it joins the semilunar ganglion of the solar plexus (p. 664). The **small splanchnic nerve** is similarly made up of fibres from the tenth and eleventh ganglia and may be traced to and through the crus of the diaphragm to the semilunar ganglion of the solar plexus. The **least splanchnic** (Fig. 365), arising from the twelfth ganglion, passes through the diaphragm with the association cord to the renal plexus. Irregularities in the origin of these nerves are frequent.

The Thoracic Nerves.—The **dorsal divisions** of these nerves have been encountered in dissecting the back (p. 581). The **ventral divisions** are the **intercostal nerves.** The peculiarities of the *first* (p. 33), *second* (p. 33) and *twelfth* (p. 16) have been noted. The intercostal nerves (Fig. 365) should be sought as they pass between the anterior costo-transverse ligaments and the external intercostal muscles and traced in their course between these muscles and the posterior intercostal membrane to the borders of the internal intercostal muscles, between which and the external intercostals they pass, below the intercostal arteries. Their further *course* and *branches* have been followed (pp. 715 and 716).

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